BRIDGING PATIENT COMPLIANCE, CLINICAL AND INTERPERSONAL SKILLS IN MODERN ORTHODONTICS AND IN ORTHODONTIC EDUCATION

Ph.D. Thesis

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I. PUBLICATIONS

I.   Baxmann M, McDonald F, Bourauel C, Jäger A: Expectations, acceptance, and preferences regarding microimplant treatment in orthodontic patients: A randomized controlled trial. American Journal of Orthodontics and Dentofacial Orthopedics 138(3): 250.e1, 2010.
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II. LIST OF ABBREVIATIONS

3D:	Three-dimensional
AI:	Artificial intelligence
AR:	Augmented reality
CBCT:	Cone-beam computed tomography
IPE:	Interprofessional education
MI:	Motivational interviewing
NLP:	Natural language processing
NOS:	Newcastle-Ottawa Scale
NRS:	Numerical rating scale
OSCE:	Objective structured clinical examination
RoB:	Cochrane Risk of Bias tool
VR:	Virtual reality

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IV. INTRODUCTION

The degree of patient expectation along with their treatment adherence stands crucial for orthodontic treatment success. Orthodontic patients enter treatment with formed beliefs about treatment pain and discomfort together with treatment effectiveness because of their personal backgrounds and use of internet resources and social influences [1–3]. Patients who believe their experiences will involve extreme pain or lengthy discomfort tend to follow treatment guidelines less than those without such expectations [4]. Psychological approaches in communication assist patients to match their expectations with true therapy results leading to better trust and compliance. Addressing these concerns is essential in an era where patient-centered care is as crucial as clinical expertise [5].

To navigate these complexities, orthodontists must integrate psychological communication skills with technical proficiency to create an experience that not only meets but exceeds patient expectations. While advancements in technology, such as cone-beam computed tomography (CBCT), three-dimensional (3D) printing, and virtual reality (VR), have improved diagnostic accuracy and treatment planning, their impact on patient experience depends on how effectively orthodontists communicate their benefits and limitations [6]. Additionally, hands-on training using typodonts ensures that orthodontists perform procedures in a way that minimizes discomfort and reinforces patient confidence [7]. By combining psychological, technical, and manual skills, orthodontic education can better prepare clinicians to enhance patient trust, improve compliance, and deliver high-quality care [3].

Orthodontic practice benefits from modern diagnostic tools along with treatment technologies which allow for better diagnosis accuracy and patient-specific treatment designs [8,9]. However, technical innovation alone serves as an insufficient condition for achieving positive patient experiences. The quality of experience patients receive comes from technological progression together with the clarity of procedure information and the establishment of realistic objectives and delivering ongoing support from orthodontists. Strong communication skills together with interpersonal abilities become essential factors that enhance the use of technology [6]. A patient will never feel comfortable with their treatment regardless of its sophistication when orthodontists do not handle expectations properly.

Thanks to online resources and social media, patients enter orthodontic treatment now demanding superior clinical results and heightened treatment experiences [2]. Commercial and health-related informational sources have transformed patients into more active decision-

makers in healthcare therefore requiring orthodontists to provide transparent explanations including risk versus benefit comparisons [3]. To meet patient demands orthodontists must provide excellent clinical expertise with patient-focused communication services [5].

The healthcare field adopts patient-centered care which addresses both medical specifics and psychological elements and patient preferences because healthcare requires a holistic understanding of treatment and health expectations from patients [2,3]. Orthodontic practitioners must recognize how patients emotionally and psychologically react to their treatment because patients feel anxious about extended procedures and have concerns about how their orthodontic appliances affect their image [10,11].

Orthodontic education requires technical skill training, psychological skills, and communication capabilities because demands are evolving. Future orthodontists need to learn advanced treatment approaches while building their capacity to handle patient expectations along with enhancing compliance goals and delivering clinical results [1,12]. Orthodontic educational programs need to merge psychological communication methods with practical treatment procedures to educate clinicians who will ultimately achieve outstanding clinical results and create pleasant patient interactions [4,13].

A. Practical training challenges in orthodontics

Limitations of traditional training

Hands-on clinical exposure of real patients has always been the traditional cornerstone of orthodontic training because it creates valuable technical skills. Traditional orthodontic education centers on teaching procedural accuracy alongside mechanical skill acquisition while most training programs currently lack specific structures that teach patients to develop accurate treatment expectations [6]. The ability to execute procedures does not guarantee that graduates will understand how to match patient expectations to treatment realities which leads to long-term patient compliance and satisfaction [2].

The main difficulty of traditional education stems from inconsistent patient cases that create variable learning experiences [14]. Different types of cases seen by students depend on what patients present at the clinic which leads to some students gaining broad clinical experience but others experiencing restricted learning of specific procedures and interactions [15]. Graduates demonstrate technical competence yet show insufficient experience in handling various patient needs especially when addressing discomfort and treatment adherence

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[3]. The training focus is on teaching students to perform procedures but they do not supply planned steps for introducing patients to discussion details regarding their treatment expectations before treatments start. Students sometimes fail to acquire communication abilities regarding pain discussions and procedural discomforts along with anticipated treatment challenges [2].

Beyond variability, real-world training presents inherent risks. Students must perform procedures under supervision before they have achieved full technical proficiency, which may lead to errors that could compromise both patient safety and student confidence [15]. Long-term orthodontic procedures with patient-needed cooperation pose special risks in the training environment according to Mahdavifard et al. [16]. Studies reveal that patient anxiety generates major compliance issues so patients either stop treatment or fail to follow through with their proposed protocols [3]. Most orthodontic teaching programs lack standardized education about handling discrepancies along with proven reassurance techniques for patients during the treatment period.

In addition to inconsistent patient exposure and procedural risks, traditional training models also lack structured reinforcement of foundational orthodontic procedures. The tasks students perform including bracket bonding, space maintenance and diagnostic planning do not ensure each student obtains the same amount of vital skill practice across the board [6]. This gap extends beyond technical skill development and into interpersonal aspects of care, such as preparing patients for discomfort, ensuring their understanding of procedural steps, and fostering trust throughout treatment [5]. Orthodontists need training for clinical skills as well as patient navigation competencies because patients today demand complete explanations alongside risk assessments with individualized treatment [2,3]. In this sense, graduates become inadequately prepared for orthodontic mental healthcare since traditional training methods fail to join psychological and communication-based instruction with technical education.

The rise of simulation-based learning

Three types of simulation techniques including typodonts, 3D models, and VR platforms let students perform bracket placement, wire adjustments and anchorage techniques without exposing themselves to patient safety concerns through actual clinical work [7]. Training tools made with dental models duplicate dimensional real procedures through a hands-on experience that removes anxiety and unknown variables from actual patient treatment [17]. The advancement of virtual reality-based training now provides orthodontic education students

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with simulated experiences for complex treatment planning of anatomical structures and biomechanical systems [18]. VR-based educational modules let students practice digital model adjustments through three-dimensional space which helps them improve their abilities before patient-based practice [7].

According to Mehta et al., simulation-based training creates an environment that allows novices to practice under safe conditions making errors for achieving mastery without harming patients [8]. Placing students through standardized practices using simulation overloads them with key procedures while ensuring all trainees receive equal fundamental lessons [7]. Thru VR devices as well as typodonts and simulation tools students develop competency in multiple clinical conditions from simple to complex situations before becoming practicing orthodontists [17].

Through simulation-based learning students receive instant feedback according to Galang-Boquiren et al. [18]. The delivery of feedback in traditional clinical settings, on the other hand, becomes delayed due to instructor unavailability combined with multiple competing administrative tasks [7]. Real-time performance analysis exists within numerous simulation systems which detects mistakes while proposing improvements [17]. The ongoing feedback system speeds up the learning process because students receive instant feedback which enables them to correct their mistakes promptly and therefore achieve better procedural skills and enhanced confidence in their execution [7].

However, simulation-based learning encounters multiple barriers which impedes its general adoption. The main challenge is cost because institutions struggle to afford maintenance and purchase of advanced simulation tools such as VR platforms, haptic feedback systems and 3D printers [17]. Technical capabilities remain a barrier because simulation tools demand specific programs, equipment and employing technical professionals to manage them [7]. It becomes challenging for educational institutions with deficient or outdated technological infrastructure and inadequate IT support teams to implement these educational tools within their curriculum [17].

B. The interpersonal side of orthodontic practice

Effective communication is a crucial aspect of orthodontic practice—patient satisfaction, treatment adherence and the overall outcome of treatment is grounded on the way orthodontists involve themselves with their patients through understanding of psychological dynamics [1,19]. Technical proficiency is a nonnegotiable quality of orthodontic care but

understanding how to connect with patients helps them understand what they can expect and earn their trust is a necessity for successful long term orthodontic treatment.

The importance of communication skills

Effective orthodontic care is based on thorough communication, which helps patients understand, and feel comfortable, with treatment choices and to follow through with recommended treatment [20]. Clear, empathetic communication can increase the likelihood of patient adherence if it assures patients that they understand the 'why' of their treatment plan, how long their treatment will likely take, and what challenges they may face on the journey. If orthodontists talk openly and in a way that is both understandable and respectful of treatment goals, the likelihood of misunderstandings and of the patient being dissatisfied at any point of treatment is far less likely.

In addition, a well informed and supported orthodontic patient is related to a happier patient [1]. Many orthodontic treatments take months, or even years, and patients can be uncomfortable, frustrated, and anxious. A key factor to positive outcome during orthodontic treatment is the orthodontist's ability to manage these emotions by listening to them and addressing concerns, providing reassurance and having an open line of communication [12]. This also adds a supportive element to treatment and ensures accountability as well as improving the perspective of the patient and thereby ensuring that they are more likely to adhere to the treatment plan.

Patients come into orthodontics with a multitude of concerns for the treatment they are going to receive, and these concerns are usually dependent on psychological and social factors. Anxiety about the treatment process is one of the most common [21]. In other words, patients may worry about the pain and the feeling of pressure of getting braces, the look of their orthodontic appliances, or how long their orthodontic treatment will take. To troubleshoot these concerns, we must know the technical aspects, but more importantly, we have to understand and gain the trust of the patient. Similarly, adolescent dental patients may have issues with body image regarding the visible dental appliances [10,11]. These concerns can have an emotional impact on the patient who can then approach or discontinue the treatment depending on his or her attitude towards the treatment.

Moreover, treatment duration is an issue. Orthodontic treatment can take a long time — months or even years — which is a big struggle for many patients, especially the young ones [1]. This long time frame also means impatience and frustration. However, concerns can be

alleviated by effective communication which establishes realistic expectations, discusses patient education, and the long term benefits of treatment.

Psychological dynamics in orthodontics

In orthodontic practice, psychological dynamics are as important as the obvious concerns. The relationship is built between orthodontist and patient based upon trust. Without trust, patients will not want to follow the treatment course (or second guess the recommendations that are provided) [22]. This trust builds when physicians take the time to listen to patients, recognize their concerns, and make all patients feel comfortable speaking with them [23]. The more trust that a patient has in their orthodontist, the more likely that patient is to follow instructions, keep appointments, and stick with a treatment that has long term ramifications.

Engaging patients is yet another major factor influencing patient behavior through motivation. Those patients who want to accomplish dental health or aesthetics will be more likely to complete the treatment process and follow through with the maintenance of oral hygiene or wearing retainers after braces are removed [24]. In addition, the orthodontist should be able to link treatment to the patient's personal goals by stressing the beneficial outcomes and benefits of a complete course of treatment [24].

On the flip side fear can be a big barrier to orthodontic treatment [4]. It could be because of fear of pain, fear of discomfort, and fear of the unknown. When treating in orthodontics, fear can be avoided if patients are clearly communicated with, educated and reassured [1]. The fear of dental procedures may even be so strong in some patients so that they avoid, or leave, treatment very early. The key to increasing the likelihood of that treatment continuing smoothly and making the patient feel supported throughout, is coming to understand and tackle these fears through empathetic communication.

The important roles these psychological aspects play in the outcome of orthodontic treatment are often neglected [1]. When patients are dismissed, made to feel they are not being understood, or go unsupported, they may become disengaged from the treatment process and hence non adherent. Miscommunications can result in misunderstandings with regards to what the treatment plan will be, how important oral hygiene is, and follow up care. This frequently leads to disappointing results, because patients choose to abort treatment prematurely or are poor compliers with care instructions, thus undermining the outcomes of treatment [4].

Current educational gaps

Clear communication and psychological understanding are of primary importance within orthodontics, yet traditional orthodontic curricula have sometimes been slow to accept these aspects for training. The majority of programs spend a significant amount of time teaching technical competencies including bracket placement, wire adjustments, and treatment planning, with very little focus on interpersonal skills [1]. As a result, many emerging orthodontists graduate with the technical knowledge to provide the care, but without the abilities to address the emotional or psychological consequences of treatment that occur so routinely.

This deficit has given rise to many adverse impacts of training in clinical practice. Take as an example, miscommunication of treatment timelines, care instructions can cause patients' misunderstanding with the treatments requirement that can lead to non-adherence or dissatisfaction. Patients who feel disconnected from treatment due to emotional (e.g. anxiety, body image) impacts of treatment fail to cooperate and their treatment experience is impaired [4,12]. Also, not taking account of these aspects can often lead to patient attrition, whereby patients prematurely abandon the treatment experience being dissatisfied with both the physical and emotional part of it. In addition, because there is no structured psychological training in orthodontic education, orthodontists are not prepared to walk through difficult conversations such as explaining delays, and complications in treatment. When such situations arise, strong communication skills help keep a patient from getting upset and to keep trusting the treatment process.

The orthodontic field is constantly evolving, as are patient expectations, resulting in the greater awareness that orthodontic education should include learning how to integrate interpersonal skills, such as communication, empathy, and psychological understanding, in the orthodontic field. Therefore, training programs that combine technical proficiency with these competencies are necessary for the production of well-rounded practitioners who can offer patients both effective and compassionate care.

C. Bridging clinical and interpersonal skills

In the fast changing healthcare landscape, orthodontic practice now demands more than technical expertise. Traditionally, orthodontic training has been dominated by a heavy emphasis on clinical skills: diagnostic ability, procedural techniques, and treatment planning, with interpersonal skills such as communication and psychological awareness a very low

priority [1]. However, these skills are inextricably linked, and there is an increasing need to integrate simulation-based and interpersonal skill training into a cohesive framework.

One thing is clear: the benefits of such integration. In real life, an excellent clinician who can do everything with the dental arches and struggle to communicate with the patient will not likely be less effective. Adherence to prescribed courses of action is compromised among patients who do not understand their treatment plans or where treatment is not supplemented by emotional support. By contrast, an excellent orthodontist may have both the strong interpersonal and communication skills needed to effectively relate to patients but not execute treatment plans sufficiently well enough, resulting in disappointed and poorly managed patients. As such clinical and interpersonal skills must complement each other to deliver the best patient care.

A solution for this challenge is to integrate simulation based training with communication and psychological skills training. Simulation tools such as typodonts, 3D models and virtual reality can be used for development of technical competency but can also be used to build scenarios to help students practice interacting with patients. Role playing exercises that can be added to and run on simulation platforms are just one example that allows the students to practice their procedural and communication skills while remaining in a safe, controlled environment. The completion of both dimensions of orthodontic care also prepares students for the reality of patient interaction - that it is a complex affair which requires both clinical expertise and empathy to generate positive outcomes.

Additionally, simulation based learning allows for learning on a consistent, repeatable, and safe platform on which to develop and refine technical and interpersonal skill sets. However, unlike other traditional clinical training that usually involves treatment of a relatively low number of cases under non predictable patient interactions, simulation provides the opportunity to provide a wide range of scenarios allowing the students to be equipped with clinical and emotional aspects of managing an orthodontic practice [1,7,12]. In the field of orthodontics, this interdependence of skills is of the essence because patient compliance and emotional support are critical to the success of lengthy and sometimes painful treatments.

Emerging educational trends

The need for integration in orthodontic education is obviously not exclusive but is a reflection of an even greater need throughout the healthcare education community for clinicians who are competent in both the technical and interpersonal aspects of patient care. Role playing

simulations and interprofessional collaborations exercises have been included in a lot of programs across medical and dental fields to promote a more wide spectrum of skills including in students [25].

In role playing simulations students participate in structured exercises in which they practice executing a treatment plan, explaining a procedure, or discussing a patient concern in a simulated setting. These exercises offer real time feedback for students to improve not only their clinical skills but also communication skills. Additionally, interprofessional collaboration exercises are performed that have dental students exchanging duties with medical professionals, psychologists, or social workers all working together to better understand the multidisciplinary aspect of patient care [25]. Localization of these exercises helps to show their importance of communication and psychological insights to collaboration and empathy between different domains of healthcare.

The efficacy of such methods is reinforced by both aforementioned literature reviews. The simulation based study found that including communication training in technical simulations significantly enhanced patient engagement and adherence, particularly when students explained complicated treatment procedures in simulations of real world challenges [7]. Similar benefits in the psychological aspects of patient care also can occur when students practice patient concerns about anxiety, body image, and receiving a diagnostic tests [1]. Proven to improve both the quality of the patient interaction as well as students' comfort in managing the psychological aspects of patient care, this combination of technical and interpersonal training is needed for future orthodontic providers.

Potential impact

A training model which unites psychological communication abilities with procedural training procedures should become essential to match patient expectations with their actual experiences. Orthodontists who assess patient concerns explicitly before starting treatment obtain the ability to fix preexisting worries that prevent patients from following their treatments. Patient education sessions prior to procedures along with data-supported pain management education help patients become better informed about their choices and enhance both their treatment cooperation and their treatment outcomes.

Manual skill training also needs to strengthen both caregiver-patient trust and confidence. Orthodontists who practice on simulation-based typodonts can develop their technical competence and master how to deliver patient-focused clinical work through this

method. The smooth delivery of dental procedures results in increased patient trust toward providers and satisfaction due to the fact that patients initially expected greater discomfort. Training with direct patient contact helps treatment delivery match the agreed-upon expectations from informed consent thus improving patient compliance and minimizing the amount of patients who stop their treatments.

Beyond direct patient benefits, integrating both communication and technical training into orthodontic education has a profound impact on professional satisfaction. The combination of clinical competency and interpersonal communication skills within orthodontists leads to increased confidence and less workplace stress and lower burnout risks. The common emergence of difficult patient encounters leads to professional dissatisfaction so training programs which teach effective expectation and concern management will result in orthodontics becoming an enduring profession with better practitioner fulfillment.

V. OBJECTIVES

The purpose of this dissertation is to span the gap between the professional and interpersonal aspects of orthodontic education. With orthodontic practice becoming more complicated, the orthodontist of the future must not only have high technical proficiency, but also the ability to communicate effectively and manage patient expectations and psychological concerns. The purpose of this dissertation is to show the necessity of bringing both kinds of skills into orthodontic training. The ultimate goal is to develop a more comprehensive training structure that equips orthodontists with the clinical acumen as well as the interpersonal capabilities necessary for success in real life practice [1,7].

In this dissertation, the use of simulation based tools such as typodonts, VR and 3D models to improve the clinical skills of orthodontic students are reviewed , with an emphasis on their role in both technical and psychological training. For those in the orthodontic field, simulation based training has provided an invaluable education tool [7]. Beyond improving technical proficiency, these tools also offer a structured way to integrate communication strategies that help align patient expectations with real treatment experiences. The promise of orthodontics is to move this proven technique into the field to not only improve students' technical skills, but also to eliminate the liability and risk that is inherent in hands on clinical training [1].

The role of communication and psychological strategies in the improvement of patient outcomes with orthodontics is a further objective. Effective communication is critical for enhancing patient compliance, satisfaction and the desired treatment outcome [1]. This dissertation will also explain the gaps in current orthodontic curricula, as discovered by Baxmann et al., in the systematic training of such interpersonal skills that necessitate further emphasis on these skills [1]. This dissertation highlights the need to train orthodontist not only in clinical but also in psychological aspects of the patient care, as neglected in traditional education [1].

This dissertation also aims to summarize the proposed methods of integrating clinical and interpersonal skill training into a cohesive education regimen. Clinical skills and interpersonal communication were traditionally taught in isolation in orthodontic education. This dissertation attempts to find ways of bringing these two together using simulation-based learning and role-playing scenarios, where students can learn how to not only perform technical procedures but also guide patients through treatment expectations and anxieties. Students can learn how to take care of the total spectrum of patient encounters by combing both communication practice and technical procedures in simulated patient scenarios. When students are trained in this integrated approach they may become more proficient in the overall skill set, becoming not only skilled in performing orthodontic procedures, but also in addressing the emotional needs of their patients. The integration of communication training modules into simulation platforms can result in a more engaged and confident practitioner, leading to improved patient adherence and overall treatment satisfaction.

The integration between emotional support and professional development holds promising outcomes for extended educational practice and patient management. Integrated training elements will produce superior real-world competencies for orthodontic students. The combination of technical and human understanding will yield improved patient results since patients who experience understanding and reassurance will preserve their treatment commitments. The integration supports orthodontists to build stronger professional fulfillment since it increases their ability to manage technical details and emotional parts when treating patients. An integrated educational framework eventually could drive orthodontic institutions to adopt patient-centered training approaches more widely which will advance the quality of orthodontic care delivery.

VI. MATERIALS AND METHODS

This dissertation combines results from three interrelated studies to develop a full orthodontic educational framework which uses patient projected outcomes alongside psychological communication approaches and clinical procedure training. Patient compliance and treatment expectations in orthodontic care serve as the focus of the initial study which identifies factors that influence patient adherence [26]. A separate investigation led by Baxmann et al. examined psychological approaches and communication strategies in helping patients adjust their expectations based on actual treatment experiences, ensuring informed decision-making and improved trust in care providers [1]. The third research study investigates simulation tools like typodonts along with VR and 3D models to train orthodontists so they can accomplish procedures according to the terms agreed upon during informed consent [7]. By integrating findings from these studies, this dissertation aims to establish an educational model that teaches orthodontists not only to execute procedures proficiently but also to manage patient expectations and enhance compliance through communication and manual skill refinement.

A. Patient expectations, acceptance, and preferences in treatment

The RCT investigated patient-reported pain perception, discomfort, and procedural preferences associated with microimplant placement, tooth extractions, and gingival tissue removal. A total of 28 orthodontic patients requiring maxillary or bimaxillary premolar extractions were recruited and randomized into two groups. Group A underwent extractions before microimplant placement, while Group B had extractions performed after placement. A split-mouth design was used, in which each patient received two different microimplant placement techniques: soft-tissue punch preparation on one side and transgingival placement on the other.

To assess procedural experiences, patient-reported outcomes were collected using a 12-item questionnaire administered before treatment, immediately after, and one week post-procedure. A five-point numerical rating scale (NRS) was used to evaluate pain and discomfort levels across treatment stages. In addition, the study measured patient preferences for transgingival versus soft-tissue punch placement. Statistical analysis was conducted using nonparametric tests, including the Kruskal-Wallis, Mann-Whitney U, Wilcoxon signed-rank, and chi-square tests, with a significance threshold of $p < 0.05$.

B. Typodont and simulation training

Under a PROSPERO-registered protocol (CRD42024560497), this systematic review evaluated the effects analogue and virtual typodont/simulation training has on orthodontic education. Specifically, data was collected on students' clinical preparedness, clinical skill development, competence, confidence levels, knowledge retention, overall clinical performance, and achievement. The review of studies analyzed the available data to enhance the understanding of how this training approach generates readiness among students for clinical practice. The review included randomized controlled trials, cohort studies, cross–sectional studies, and qualitative studies. Studies not in the scope of orthodontic education, not relevant to typodont or simulation training, and non-English publications were excluded to have a specific homogenous dataset for analysis.

A broad spectrum of eligible studies was sought using a comprehensive search strategy. PubMed, the Cochrane library, ERIC and CINAHL were queried using the keywords "typodont training," "simulation training," "orthodontic education," "clinical preparedness" and "virtual training." Reference lists of selected studies were searched for additional articles; gray literature was also searched, namely conference abstracts, institutional publications, and dissertations. The same screening process, using already established inclusion and exclusion criteria, was applied to identified gray literature as for database sourced studies. The reliability was judged based on relevance, methodological soundness, and data availability.

Data were extracted using a standardized form, by two independent reviewers to maintain consistency across all included studies. Information about study design, participant details, training methods, measured outcomes and key findings were extracted. Discrepancies between reviewers during study selection or data extraction were resolved through a structured process: Disagreements were first discussed and debated, a process after which unresolved issues were referred to a third reviewer for a final decision. This systematic approach improved transparency, minimized the opportunity for bias, and provided consistency in data gathering while providing a solid base from which to synthesize the findings.

The Cochrane Risk of Bias (RoB) Tool was used to assess randomized controlled trials in order to examine potential biases for each domain [27]. For observational studies, the Newcastle-Ottawa Scale (NOS) provided a systematic approach to assign a star rating to participant selection, group comparability and outcome assessment was used [28]. For these evaluations, as with data extraction, two reviewers independently performed these, and

disagreement about any data points was resolved by discussion between reviewers with any disagreements resolved by a third.

Due to the differences in study design, training goals and outcomes measured, a narrative synthesis of the findings was used to provide a main summation of the results of the included studies and identify common themes across them. Using the GRADE framework allowed evaluation of overall quality and strength of the evidence within a structured assessment of confidence in aggregated findings and their relevance to orthodontic education and policy development [29].

C. Psychology and communication skills

PRISMA guidelines were followed in this systematic review therefor allowing for a thorough and transparent reporting. The protocol was registered with PROSPERO (ID: CRD42024560432) and study selection was according to well defined PICOS criteria. The practice population of interest was orthodontic patients, and the interventions focused on communication and psychological strategies used in practice or training of orthodontic treatment. Studies analyzing different methods of communication and psychological approach or no such interventions, were compared. Outcomes measured included patient satisfaction, adherence to treatment, psychological outcomes, and humanistic outcomes, such as quality of life, autonomy, safety, and intimacy. In reviewing the evidence for this review, randomized controlled trials, observational studies and qualitative research were included covering a broad range of evidence related to the objectives of this review.

A multiple databases search was conducted in PubMed, the Cochrane Library, ERIC, and CINAHL. Keywords used in the search strategy included variations of "orthodontic practice," "psychology," "communication skills," "patient management" and "educational curriculum." In order to supplement database searches, reference lists of pertinent articles and a search of gray literature sources were conducted to identify other relevant studies that met the inclusion criteria.

To keep precision and consistency, two independent reviewers performed data extraction using a standardized form. Study design, participant demographics, psychological and communication training characteristics, outcome measurements, and key study findings were collected. By this systematic approach, a thorough evaluation of the educational practices identified could be made. The risk of bias in the studies was assessed using validated tools: The Cochrane RoB Tool was used for randomized controlled trials and the NOS for

observational studies [27,28]. Two reviewers independently conducted assessments, and disagreements were resolved by consultation with a third reviewer. Qualitative summary of results was done using narrative synthesis which focused on key themes and patterns across different studies.

VII. RESULTS

The RCT by Baxmann et al. assessing patient expectations, acceptance, and procedural preferences for microimplant placement yielded significant findings on pain perception and treatment adherence [26]. Among the 28 orthodontic patients, overall pain perception varied significantly across different procedural stages ($p < 0.05$), with extractions being rated as the most painful procedure, followed by soft-tissue punch preparation and transgingival placement. Patients reported lower pain scores for transgingival placement (median: 1.6, IQR: 1.2–2.1) compared to soft-tissue punch preparation (median: 2.4, IQR: 1.9–3.1), with the difference reaching statistical significance ($p = 0.03$). When comparing pain levels across extractions, soft-tissue punch, and transgingival placement, analyses indicated significant variation ($H(2) = 13.92$, $p < 0.001$), with post-hoc analyses confirming extractions were significantly more painful than both microimplant procedures ($p < 0.01$). Analysis of patient preferences indicated that 72% of participants preferred transgingival placement, citing lower discomfort and shorter procedural time ($\chi^2(1) = 6.02$, $p = 0.014$). Patient willingness to undergo future microimplant placement was significantly higher in the transgingival group, with 84% expressing no hesitation, compared to 57% in the soft-tissue punch group ($p = 0.028$). Additionally, discomfort ratings assessed at three time points (pre-treatment, immediately post-procedure, and one-week follow-up) revealed a statistically significant reduction in reported discomfort over time across both microimplant groups ($p < 0.001$), suggesting that initial procedural discomfort declined substantially within one week post-placement.

The typodont and simulation article by Baxmann et al. yielded 531 initial references from a comprehensive search of PubMed, Cochrane Library, ERIC and CINAHL databases [7]. From this sample a further 189 records were then filtered out (with 47 duplicates first eliminated) due to irrelevance to orthodontic education or non-English language content. This resulted in 295 records to be screened further by titles and abstracts. The first stage removed 231 records from which did not meet inclusion criteria. Sixty four full text articles were then retrieved in order to undergo more detailed assessment, and finally 11 studies were included in the final analysis (see Figure 1).
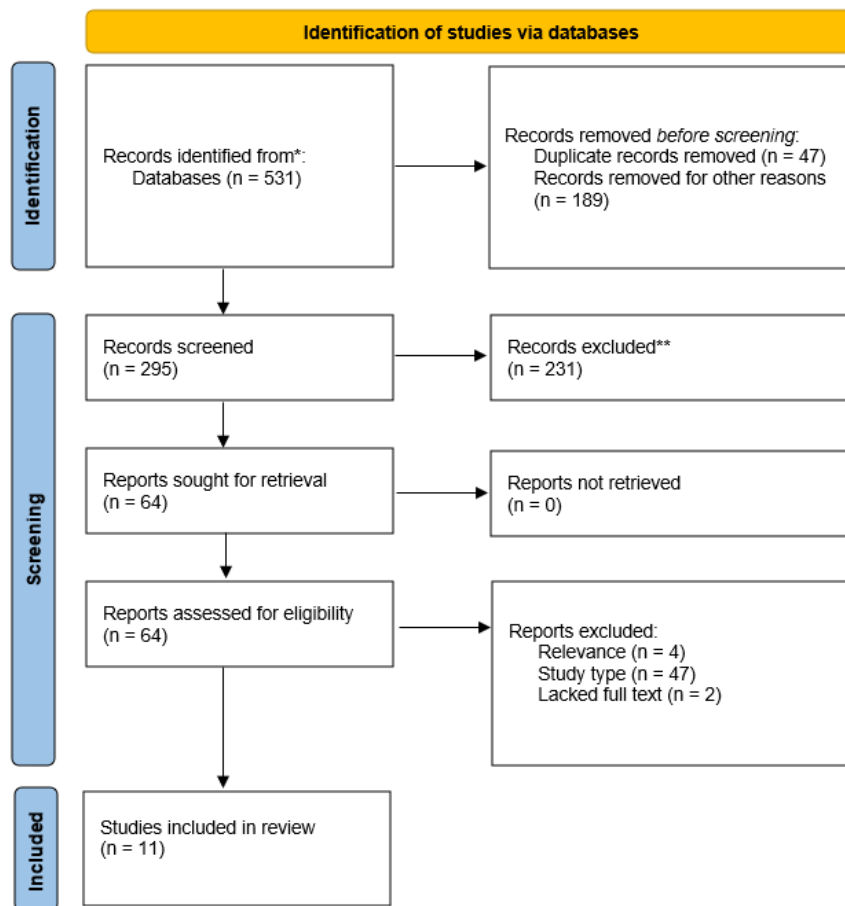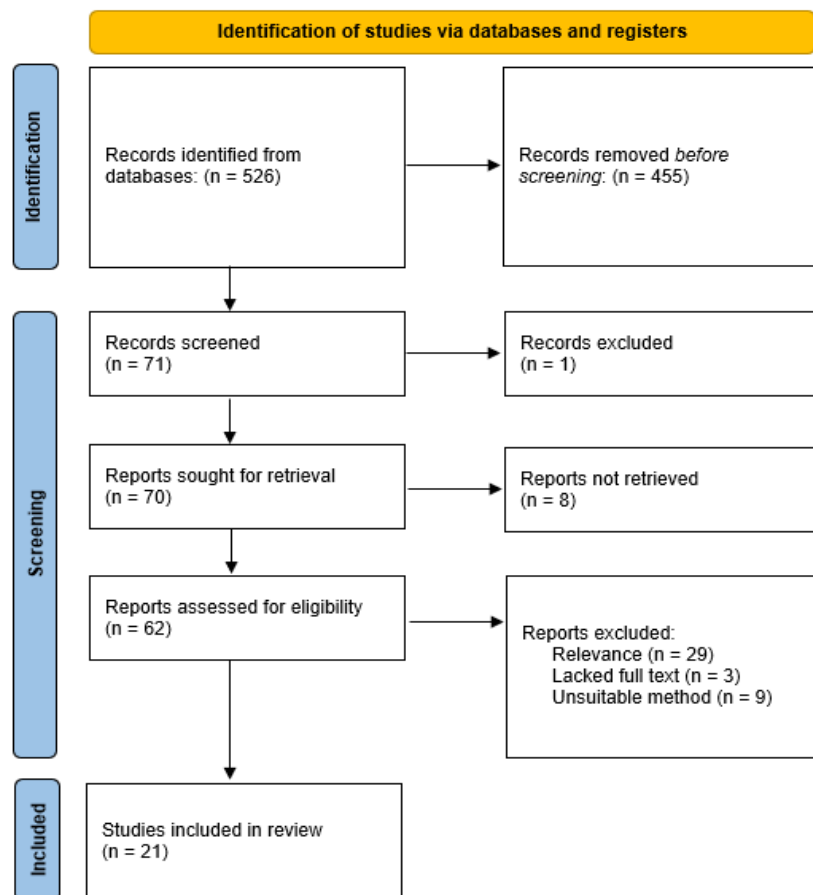
Figure 1. PRISMA flow diagram [7]

The studies included had various designs such as randomized controlled trials, quasi experimental studies, cross sectional surveys, mixed methods and Delphi methods. The sample sizes of participants were on average 10 to 108 and were to a significant degree orthodontic students. They examined the use of training methods that varied across studies, such as VR simulations, case based education, blended learning, 3D printed models and scenario simulations. Outcomes related to these studies included student perceptions, learning motivation, communication skills, and diagnostic performance and together, they provided a broad literature on the efficacy of typodont/simulation training in orthodontic education.

A low risk of bias existed for the majority of key domains of the reviewed randomized controlled trials. Randomization process, deviations from intended interventions, and handling of missing outcome data had a low risk in all studies. However, in two studies, some concern existed as outcomes were measured using self-report, however, where outcomes were measured, the overall bias was low. Overall, all domains had consistent low risk of bias (Table 1). Additionally, quality of the observational studies included was generally high. The vast majority of studies attained the maximum score for outcome assessment and most attained

strong scores in both the selection and comparability type of study. Scores ranged from 6 to 9 (median of 7) suggesting low to moderate risk of bias (Table 1).

The initial database search for the psychology and communication article by Baxmann et al. yielded 526 records from which 455 were removed before the screening stage [1]. A total of 71 records were screened and one was excluded at this stage. The remaining 70 records were attempted for retrieval, but 8 could not be accessed. Sixty two of the full text reports then obtained were assessed for eligibility. Of these, 41 were excluded for various reasons. Consequently, the final analysis comprised 21 studies (see Figure 2).

Figure 2. PRISMA flow diagram [1]

Using the NOS, summarized in Table 1, the risk of bias for the included observational studies was assessed. The scores ranged between 5 and 9 total scores indicating varying quality in the methodology used in the studies. The Cochrane RoB tool was used for the RCTs. A generally low risk of bias was reported in most domains except for the blinding of participants and personnel in one article. Some of the domains of uncertain risk, in particular random

sequence generation, allocation concealment, and blinding of outcome assessment, among others, are associated with possible biases affecting the validity of their study.

Table 1. Cochrane risk of bias and NOS outcomes [1,7]

Study	Risk of Bias Tool	Risk of Bias Outcome
Alhaija et al. (2018)	NOS	9 (Low risk)
Al-Jobair and Al-Mutairi (2015)	NOS	7 (Low risk)
AlKharafi et al. (2014)	NOS	7 (Low risk)
Al-Silwadi et al. (2015)	Cochrane RoB	Low risk in all domains
Amado et al. (2008)	NOS	8 (Low risk)
Balos Tuncer et al. (2022)	NOS	7 (Low risk)
Bibona et al. (2015)	NOS	6 (Moderate risk)
Brown and Inglehart (2011)	NOS	6 (Moderate risk)
Catt et al. (2018)	NOS	8 (Low risk)
Chen et al. (2023)	Cochrane RoB	Low risk (randomization, deviations, missing data); Some concern (self-reported)
Choudhry et al. (2017)	NOS	5 (Moderate risk)
Cozzani et al. (2016)	Cochrane RoB	Low risk in all domains
Ho et al. (2022)	NOS	6 (Moderate risk)
Huang et al. (2022)	NOS	7 (Low risk)
Kaggal Lakshmana Rao et al. (2020)	NOS	8 (Low risk)
Lai et al. (2024)	NOS	9 (Low risk)
Le Fouler et al. (2021)	Cochrane RoB	Unclear risk in allocation concealment and blinding; High risk in blinding of participants and personnel
Lee et al. (2022)	NOS	8 (Low risk)
Lin-na et al. (2023)	Cochrane RoB	Low risk (randomization, deviations, missing data); Some concern (self-reported)
Liu et al. (2022)	NOS	7 (Low risk)
Maresca et al. (2014)	Cochrane RoB	Low risk (all domains)
Mehra et al. (1998)	NOS	5 (Moderate risk)
Mirmoghtadaie et al. (2022)	NOS	7 (Low risk)

Randall and Dhar (2023)	NOS	5 (Moderate risk)
Stonehouse-Smith et al. (2022)	NOS	5 (Moderate risk)
Taibah (2018)	NOS	5 (Moderate risk)
Zhao et al. (2024)	NOS	6 (Low risk)

Some common challenges were apparent across both sets of studies. Technology was viewed as important to the quality and access for simulation based training. The limiting factor, however, was that many institutions did not have the tools to offer the most cutting edge training techniques, to deliver consistent results from education setting to education setting [7]. The cost of VR systems and 3D models was high, which together with student perception of additional workload were perceived as barriers of mass acceptance of these techniques in education [7]. However, communication training had problems due to such curriculum restricted inclusion. While many orthodontic programs tend to emphasize technical competencies for orthodontists and neglect the soft skills that allow them to communicate effectively with their patients, the belief that orthodontists benefit from knowing more about how patients think and feel regarding their facial appearance influences the curriculum [1]. Additionally, a dearth of long term evaluations of the effects of communication training on patient outcomes, precluded the ability to discern the long term benefits of these training programs [1]. Although simulation and communication skills are important pathways to comprehensive orthodontic education, both must overcome these barriers to realize their potential to increase student preparedness and improve patient care (Table 2).

Table 2. Summary of included studies in the reviews [1,7]

Study Focus	Number of Studies	Main Findings	Challenges Identified
Simulation-Based Training	12	Significant improvements in technical skills (e.g., bracket bonding, treatment planning). VR and 3D tools provided immersive, risk-free environments to practice skills.	Variability in technology quality and access; high cost; perceived workload for students; inconsistent use across institutions.
Communication & Psychological Skills	20	Structured communication methods improved patient adherence, satisfaction, and treatment compliance.	Limited inclusion of communication training in curricula; lack of long-term evaluation of patient outcomes.

		Techniques like motivational interviewing and digital reminders were particularly effective.	
Overall Challenges	32	Simulation tools enhanced procedural confidence and diagnostic precision; communication training improved patient outcomes.	Barriers to the adoption of advanced simulation tools; communication training underrepresented in curricula.

VIII. DISCUSSION

The dissertation establishes a connection between research in three orthodontic education domains including patient expectations and treatment compliance as well as psychological approaches/communication methods and simulation-based training. Knowledge about patient dental treatment expectations together with their impact on treatment compliance helps build stronger orthodontic results [1]. The occurrence of unrealistic patient expectations regarding pain sensations as well as discomfort and procedural intricacies leads to noncompliance challenges which supports the necessity of psychological communication training for orthodontists to provide informed patient guidance [4,30].

The educational standards for orthodontics have to teach practitioners the necessary skills for both patient-need resolution and procedure execution which meets patient expectations. The field of simulation-based training employs VR and 3D models together with typodonts as fundamental instruments for clinical skill advancement through safe controlled environments [7]. Repeated procedural practice during training allows orthodontic students to develop their technical skills and gain confidence to provide care to live patients. However, technical skills alone are insufficient—effective treatment delivery also requires communication strategies that support patient trust and compliance.

Implementation of simulation-based training together with structured psychological and communication techniques will make orthodontic education more effective at preparing future clinicians to handle patient interaction complications. This discussion assesses integrated educational approaches through an assessment of their challenges and advantages which merge clinical competency with communication abilities to deliver superior treatment outcomes. Additionally, it considers the barriers to implementing this approach, including curricular

constraints, accessibility of simulation technologies, and faculty readiness to adopt new teaching methodologies.

A. Patient expectations, acceptance, and compliance

Summary of key findings

Patient perceptions of orthodontic procedures influence treatment adherence and overall compliance [26]. The perception of pain was the main reason for non-cooperation among patients, especially regarding extraction procedures and the subsequent steps of soft-tissue punch preparation and transgingival microimplant placement [26]. Chosen by most patients was transgingival placement because it reduced patient discomfort and procedural challenges [26]. The transparency of procedures and the delivery of effective communication according to patient adherence frameworks resulted in diminished anxiety and resistance towards orthodontic treatment [26]. Understanding procedural timelines together with anticipating discomfort allows patients to trust the treatment recommendations more effectively thus demonstrating the importance of structured communication training in orthodontic education.

Barriers and challenges

Patient expectation management suffers from diminished effectiveness because of different methods used to counsel patients before procedures [31]. The procedures performed by some practitioners include formal discussions about pain management followed by clear explanations while different providers give limited information which causes patients to develop mismatched expectations. Standardized communication approaches are essential since patients who receive inconsistent information develop excessive treatment fears which could cause them to stop following instructions or end their care prematurely [32]. While procedural discomfort declines over time, initial negative experiences impact long-term cooperation, particularly in treatments requiring extended interventions. Negative early experiences contribute to missed follow-up appointments, inconsistent appliance wear, and reluctance toward further procedures, making patient engagement strategies a critical component of orthodontic education [33,34]. The lack of training on patient compliance management results in higher practice variation. The main focus of orthodontic educational programs remains technical skills education rather than structured instruction about behavioral management approaches and patient adherence methods [1,7,26]. Orthodontists who lack training in these

subjects face difficulties in handling patient issues as well as reducing stress and enhancing patient cooperation during their practice.

Solutions and future directions

Student education in orthodontics supported by patient-oriented communication methods leads to better compliance and treatment participation from patients [1,26]. Training modules about pre-procedural counseling should be added to education programs to help students learn effective ways of describing treatment procedures and preventing patient concerns while enforcing compliance standards. Simulation-based training has the potential to upgrade this method by enabling students to work with virtual patients for complex treatment explanation practice and procedural concern resolution in simulated environments [7].

Post-procedural engagement strategies also play a role in sustaining adherence. As procedural discomfort diminishes with time, structured follow-up consultations, digital check-ins, and patient reminders could reinforce long-term compliance [26,35]. Implementing interactive patient education materials, including visual treatment timelines and multimedia resources, may further reduce procedural anxiety and improve patient understanding. However, bridging the gap between technical proficiency and patient-centered care requires orthodontic programs to place equal emphasis on clinical training and behavioral science principles. Incorporating expectation management, procedural transparency, and patient adherence strategies into the curriculum can equip future orthodontists with the skills necessary to optimize patient outcomes [36].

B. Simulation-based training in orthodontic education

Summary of key findings

Simulation based training has been an essential aspect in the development of orthodontic education. According Baxmann et al., VR, 3D models, and typodonts are powerful tools for improving students' technical skills, particularly for complex procedures (e.g. bracket bonding, treatment planning, and clinical reasoning) [7]. The application of these tools to simulation provides a controlled, risk free environment in which students can practice repeatedly to enhance procedural confidence and diagnostic accuracy [37].

VR systems have demonstrated potential for orthodontic education to provide improved procedural skills. VR simulations are an immersive experience that allow every student to practice using hands on realistic techniques [38]. For example, Chen et al. found that students'

diagnostic performance and learning satisfaction improved more significantly in VR simulations than in traditional approaches, for instance, those built upon PowerPoint [38]. VR helps boost students' confidence in that it allows them to practice repetitively in a virtual environment and cut down on errors when these students eventually work with real patients [38].

Besides VR, 3D printed models have also made a huge contribution to the development of technical skills. Lin-na et al. asserted that these models aid students to practice orthodontic procedures with realistic tactile feedback, which is essential for developing manual dexterity essential in clinical practice [39]. Another important tool is typodonts which allow the students to practice bracket placement and bonding in an environment that is as close to the clinical situation as possible. While less developed than VR and 3D models, these tools still provide a great way to practice students, particularly with their ability to build procedural confidence, along with their ability to learn basic orthodontic techniques [40].

Barriers and challenges

While promising findings from simulation based training exist, its integration into orthodontic education is not without considerable barriers. A key problem is the variability of technology quality and the uneven recourse to simulation tools educational institutions [7,41]. Also as Maresca et al. pointed out, while some institutions have put significant funding into the high-end VR systems and 3D printing technology, there are many others especially that do not have a big budget and find difficulty providing their students with the access to these advanced tools [42]. As such, learning experiences are disparate, with students at wealthier institutions having access to the very latest in technology, while other students are even missing the very most basic simulation tools.

Apart from technology quality and access, the cost of these tools remains a formidable barrier. Each article shares the surprising costs associated with purchasing high quality VR equipment, 3D printers, and typodonts. But these tools can be expensive, and they are often compounded by the ongoing maintenance costs needed to keep these tools current. For example, some VR systems require frequent updates of both software and specialized equipment just to work on them, something which may be unaffordable for smaller or underfunded institutions [42]. Moreover, the training costs for faculty members who have to learn how to successfully utilize such tools increase the financial cost, making it hard for institutions to invest in large scale adoption [37].

Another issue found is the perceived workload for students. Simulation based training provides a tremendous amount of value and takes a lot of time and effort. For instance, they may have to put in many hours of practice with VR simulations or 3D models along with what is already in their busy academic schedule. Student burnout can arise from the amount of time commitment required for these online classes from the discussion noted by Huang et al. [37]. Additionally, many of the students report that they are overwhelmed by the content and practice needed to master these simulation tools, possibly turning them off from using these technologies [7]. Furthermore, these tools may also be integrated into the curriculum policy, with resistance within environments, in terms of additional time needed for both students and instructors to incorporate new teaching/learning methodologies [41].

Finally, the challenge to broad use is that they are not widely adopted in educational institutions due to inherent unevenness in adoption. According to Kaggal Lakshmana Rao et al. many orthodontic programs still rely on old ways of training which give priority to direct patient care in the place of simulation [41]. However, cultural resistance to technological innovation further contributes to inequity in access to high quality training, as use of simulation-based tools are often delayed [41]. These barriers argue for a systemic approach to simulation based training in an orthodontic curriculum to ensure that all students, regardless of institutional resources, can use simulation.

Solutions and future directions

Although the barriers are formidable, a number of solutions and potential future directions are discussed to improve simulation-based training in orthodontic education. Limited access to simulation tools is one possible solution to the access problem that can be solved by creating partnerships between educational institutions and technology providers [41]. Collaborations like these could enable resources to be pooled with less well funded institutions obtaining access to equipment, so the most advanced simulation tools could be widely available to schools. Moreover, universities may work with industry partners to acquire advanced technological development through sponsorships or grants, ensuring all universities have state of the art training development [7].

Another promising solution is the development of cost effective simulation tools. High end VR Systems and 3D printers are expensive but more options for low cost are being made available. For example, financially struggling schools may find their problems solved by a more affordable 3D printing option, or an open-source or low cost VR platform [37,42]. As

technology advances these inexpensive options could slash the cost of simulation based training by so much that all students will enjoy the benefits from this type of learning.

Simulation based training must therefore be integrated into a traditional curriculum in such a way that the blend between simulation and hands on practice and learning is seamless [7]. Including simulation tools into the curriculum can expose students to real world skills to practice (in a controlled environment) prior to placement in clinical settings [7]. VR simulations can be used, for example to practice treatment planning and diagnostic skills, before the students have to work with the patients themselves. Using this approach, students are better prepared for the challenges of the practice of orthodontics in the real world having less errors and better results for patients [37].

Also, having faculty development is essential to affect the successful integration of simulation based tools in orthodontic education. According to Liu et al., instructors need to be trained not only on how to use these technologies but also on how to use it in an appropriate manner of the course [43]. Creating workshops and seminars that provide professional development for faculty, in the form of simulation based teaching, will provide faculty with the opportunity to use simulation tools to the fullest extent possible [43]. Additionally, faculty should be trained to determine a good work load for a student as they move forward with learning and using simulation.

With orthodontics becoming a progressively advancing field, emerging technologies have promise to further improve clinical and interpersonal training. Artificial intelligence (AI), another such innovation, is being increasingly employed in diagnostics, treatment planning, and education [44]. AI driven platforms can evaluate patient data to generate specific treatment suggestions, but likewise serve as learning tools that mimic complex case situation [45,46]. For instance, machine learning algorithms, as well as other algorithms, are able to find trends within the data and predict what the results will be just like predicting the results of a standby procedure during a procedure, learning from the data in regard to which techniques work best on certain types of patients, and so on.

Augmented reality (AR) is also another promising avenue and has already started to find application in surgical training and could be adapted for orthodontic education simply [47]. AR performs the operation of overlaying virtual elements to real world scenario which facilitates to practice procedures or to visualize the anatomical structures in an immersive and

highly interactive way. Unlike traditional methods, AR helps close this gap in between theory and its own practice by giving real time feedback.

In addition, haptic feedback technologies have been used to leverage simulation training by reproducing the tactile sensations of clinical procedures [48]. Not only do these systems help students to refine their manual dexterity, but the sensory experiences also that result from using these systems prepare them for the sensory experiences of real world practice. With communication modules, such as virtual patients or role playing exercises, these tools combine to create a 360-degree education package that develops technical and social skills at the same time.

Lastly, virtual patient avatars with natural language processing (NLP) can empower the training of students in the communication skills [49]. Since these virtual patients can show a variety of emotional and behavioral reactions, students can practice empathy, manage patient anxiety, and fine tune their ability to explain complicated treatment plans effectively. Despite the tremendous potential of these technologies, they cannot be integrated into orthodontic curricula without well-articulated pedagogical frameworks and a sound empirical base. Therefore, it will be essential to conduct research on their long term effectiveness as well as cost-benefit analysis and evaluating the accessibility for institutions who have fewer resources to adopt them more equitably.

C. Communication and psychological skills in orthodontic education

Summary of key findings

Good communication and psychological skills are a must have in orthodontic care and their development is essential orthodontic education. Using motivational interviewing, empathy based training, and patient education can increase patient adherence, satisfaction, and success in overall treatment significantly [38,39]. While these skills have, at times, been deemphasized in traditional orthodontic curricula, they are essential skills for handling patients' emotional and psychological needs as well as meeting their clinical needs [1]. Psychological strategies that integrate anxiety management and/or expectation settings are demonstrated to reduce patient treatment related anxiety and improve the overall patient experience [1].

The key findings of the studies are motivational interviewing (MI) and empathy training that improves the level of patient engagement into their treatment planning. MI techniques aim

to treat the patient's personal motivations and lead them to make their own informed choices regarding their orthodontic needs [38,50]. Through creating this collaborative bond between orthodontist and patient, this technique group achieves higher treatment adherence [51]. The procedure of MI helps patients express their reasons to continue the treatment process, which in practice helps maintain what the patients have already started [52].

The studies also demonstrate that empathy based training has positive effects on patient satisfaction. Since orthodontic treatments usually take months, if not years, patients frequently experience anxiety and stress about it [39]. Active listening to patient concerns and compassionate communication can help put an end to this orthodontic anxiety and make the patient experience a positive one [39]. These strategies help to build a strong therapeutic alliance between patient and orthodontist, increasing patient's feeling of understanding and respect and, therefore, trust about the clinician's judgment.

Moreover, patient education is shown to be a vital part in improving treatment outcomes. Expectations are set with educating patients about what their treatment is, what to expect from it, and why others should follow the care regimen. The studies encapsulated by Baxmann et al. conclude that when orthodontists are able to explain to patients in a manner, which is clear, and are empathetic with processes, goals and possible complications leading to the treatment help patients to understand that for successful treatment outcome their role is important [38,39]. This proactive approach to communication leads to better patient compliance, fewer misunderstandings, and higher overall satisfaction.

Integration of communication in orthodontic education

However, despite documented benefits of communication skills, they insufficiently permeate the traditional orthodontic education [1]. Orthodontic programs historically have paid more emphasis to the development of technical skills compared to communication and psychological strategies [38,39]. The outcome is orthodontic graduates who are strong performers of technical procedures but perhaps less capable of managing patient relationships well. A clear gap in training exists and subsequently can result in suboptimal patient interactions, reduced patient satisfaction, and incomplete treatment adherence, all of which undermine the clinical success of orthodontic interventions [1].

The importance of patient centered care as an important reason for prioritizing communication skills is clear. Clinicians are encouraged by patient centered approaches in the delivery and planning of care while taking into account individual patients' preferences. The

reason that this approach is so important in orthodontics is that treatments can be so long term and also may have multiple phases. If patients perceive that there is no effective communication, the result may be patients feeling ignored or demotivated about the progress on their treatment, and therefore non adherence and dissatisfaction [1]. The incorporation of communication skills into orthodontic education will allow students to diagnose and treat not only orthodontic conditions but will also give them the skills to provide care that is effective clinically and emotionally supportive overall for better treatment outcomes.

Patient centered care and empathy are key elements of effective orthodontic communication while cultural sensitivity is an equally important aspect when communication needs to be accomplished in increasingly diverse orthodontic patient populations. Communication in orthodontic care is effective when not only general interpersonal skills are mastered, but also cultural sensitivity [53]. The cultural background of patients affects how patients perceive their treatment, how they would like to communicate with their doctors, and how they will respond psychologically to orthodontic care [54]. For example, patients from different cultures may be more willing to express concerns, accept treatment regimen, or participate in shared making of decisions. As such, cultural competency must therefore be integrated into communication and psychological training (as part of orthodontic dental practitioners' preparation) to deal with these conversations which are so fraught with nuances.

Culturally sensitive communication strategies can be designed into simulated patient encounters with diverse cultural scenarios. Such training, for example, might teach how to resolve misunderstandings caused by linguistic barriers, or approach patients whose belief in holistic health takes primacy over conventional treatment. Motivational interviewing techniques could be 'humanized' by incorporating cultural sensitivity into how these techniques can align treatment plans with patients' personal values and beliefs and improve patient adherence. Similarly, cultural stigmas regarding orthodontic treatments, like one's aesthetic or prioritization of financial over the treatments in such communities can be taught in empathy training.

In this sense, it is vital that psychological strategies be integrated into orthodontic curricula. In orthodontics, where treatment can be uncomfortable, long and resulting in major changes to the face, it is extremely important that patients work with a team who can help them manage anxiety and set realistic expectations. Training orthodontic students in these skills prepares institutions to graduate practitioners who are globally ready to impart both the

technical and psychological aspects of orthodontic care. The whole approach helps the patient and clinician, as a better patient engagement as well as smoother patient compliance lead to better clinical outcomes [38].

In addition, orthodontic education must build upon the necessity of effective communication and psychological strategies complemented by the important element of health literacy to increase patient understanding and involvement for the sake of a positive treatment result. Health literacy barriers are a major, yet often ignored, component of engaging in effective orthodontic communication [55]. Orthodontic care depends significantly on health literacy, essentially the patients' ability to access, process, and understand the basic health information necessary to make informed decisions [56]. This is especially applicable given that orthodontic treatment plans can be quite complex, technics, long term commitment, patient adherence to treatment plan.

Those with limited health literacy may not understand the meaning of their treatment with orthodontic treatment, including the steps to success, the risks involved, and long term advantages. Gaps in understanding can lead to lower treatment adherence, more anxiety and outcome dissatisfaction [50]. For instance, when a patient does not understand the significance of continuing oral hygiene during orthodontic treatment, by making a mistake such as leaving teeth unclean they can jeopardize the outcomes of their care, for example decalcification or gingival inflammation.

Due to these challenges, orthodontists must resort to strategies adapted to different levels of health literacy. Plain language, graphics and interactive methods of communication can help bridge all these gaps [57,58]. For instance, utilizing videos, infographics, or even virtual reality simulations in patient education makes it easier to understand. But such tools do not just simplify complicated information; they also get patients to be more proactive about their treatment journey altogether.

In addition, orthodontic education and training must be built on health literacy. Teaching future orthodontists how to judge their patient's understanding, adapt a communication strategy, and use culturally appropriate approaches to serve a diverse patient population should be paramount in all programs. Illustrative scenarios for simulation based training might include patient interactions with varying health literacy levels to exercise students in tailoring targeted communication approach in a controlled environment. By

prioritizing health literacy in communication, orthodontic care becomes more inclusive, effective, and patient-centered.

Implications for curriculum design

Several combinations of simulation based learning with communication and psychological training can revolutionize current orthodontic education. However, traditional curricula are still often over focused on technical proficiency, and by incorporating courses that support interpersonal and emotional intelligence, graduates leave the programs with a more rounded knowledge of being a professional. Through the addition of virtual simulations and typodont exercises, along with role playing scenarios, students are able to acquire technical expertise alongside a development of the soft skills vital to interaction with patients.

The adoption of hybrid learning modules is one of the most promising outcomes of curriculum innovations [59]. For example, an orthodontic training session, following a typical one, may begin with a virtual reality simulation of bracket placement and then be followed by an exercise that involves students practicing what they will say to a patient who seems nervous. These technical precision and empathetic communication examples reflect real world applications of care and prepare students to deal with complex clinical and interpersonal issues.

Additionally, building of these skills longitudinally across the length of the program can support learning. This could be done, for example, early year students doing foundational simulations developing diagnostic confidence, to the most advanced students doing comprehensive simulations related to ethical dilemmas or dealing with dissatisfied patients. With this progression, students graduate with both the hands on technical skills and emotional intelligence necessary for delivery of high quality orthodontic care.

As such, the introduction of these hybrid curricula is also consistent with the general direction of healthcare education, including interprofessional education (IPE). Orthodontic programs can work with psychology, counseling, and/or social work departments to expose students to interdisciplinary perspectives which will enhance their patient care in a more holistic manner [60]. For example, clinical psychologists could be invited to co–facilitate workshops on how to manage patient anxiety to enhance student understanding of behavioral techniques, such as motivational interviewing or cognitive restructuring.

Since communication and psychological skills are gaining prominence in the core of curriculum design, it is equally essential to develop strategies for valid evaluation of these skills

based on educational goals. Therefore, there are clear needs to develop robust methods of assessment of communication and psychological skills of orthodontic students. However, traditional assessments, such as written and practical demonstration exams, do not always measure the intricate, person-to-person, and emotional competencies needed for superior patient care [61]. As a result, innovative and multidimensional assessment tools are required.

Simulated patient interactions represent one of the most effective ways of evaluating a doctor's communication and psychological skills [62]. This means that in such cases, students become involved with actors or standardized patients posing challenges, for instance how they manage patient's anxiety, how they explain complicated procedures or how they deal with patient's dissatisfaction with treatment outcomes. These simulations are then recorded and rated using structured (that is, rubric-based) checklists focusing on active listening, empathy, and delivery of information.

Besides simulated patient scenarios, peer and faculty feedback are part and parcel of developing our ability to reflect upon and improve ourselves. Following simulations or clinical encounters, students receive feedback structured in sessions, where students realize their strengths and where they need to improve. Some faculty taught with some training in communication and psychological strategies can offer some targeted types of help, and peer evaluations are a very good form of collaborative learning [63].

Clinical competencies such as communication skills have come to be regarded as a gold standard, tested with objective structured clinical examination (OSCE) [64]. Each of these exams consists of multiple stations where the students must perform given tasks including interviewing patients, resolving conflicts, or conveying treatment plans. A standardized rubric is used to evaluate each station, which guarantees consistency and objectivity in assessment. Also, another strategy is to encourage students into self-assessment and reflective practice. Students can examine their own communication style and psychological approach through reflection journals, self-evaluation forms and guided discussions. The other thing that this practice does is fosters lifelong learning, which means that students remain adaptable to diverse patient needs [65].

Barriers to effective communication training

Clearly integrating communication skills in orthodontic education has its benefits, but there are several barriers that prevent the communication skills integration. One of the greatest hurdles is a lack of communication skills training in the standard orthodontic curriculum [12].

The dominance of technical training in orthodontic programs is unbalanced, hence eliminating the opportunity to embed communication training. As pointed out by Liu et al., many orthodontics programs still place significant focus on developing the clinical skills such as diagnostics accuracy and treatment planning to the detriment of more interpersonal aspects of their care [43]. The lack of emphasis on communication training results in a generation of orthodontists technically capable, but sometimes inept at patient management.

One barrier to effective communication training is that curriculums are limited. Orthodontic curricula are dense and provide little time for patient communication training as they are designed for technical and clinical practice [39]. Time is often tight to integrate communication training with an already crammed curriculum—and there is little understanding that developing these skills will pay off in the long run. In addition, orthodontic programs often lack dedicated resources or faculty for communication skill teaching, leading to students not receiving adequate or consistent communication skill training [12].

The under-integration of communication skills into orthodontic curricula is further influenced by faculty resistance as well. Communication training is thought by many instructors, and instructors with technical training backgrounds in particular, to be less important than clinical instruction [12]. Moreover, there is generally no faculty experience on communication and psychological strategies to facilitate their effective teaching to students [1]. If students do not have these faculty that are proficient in most or all of these areas, these students will not receive the necessary guidance to develop the appropriate interpersonal skills needed.

Finally, these barriers are amplified by the institutional focus on technical (hard) skills. However, most orthodontic institutions have kept the clinical and technical instruction priority at the expense of soft skills. As Huang et al. noted, many programs still have a strong reliance on traditional pedagogies emphasizing hands on clinical practice with minimal space for incorporation of psychological and communication training [66].

Challenges and opportunities across diverse educational settings

Challenges facing the integration of communication and psychological training into orthodontic education are particularly in diverse educational contexts. The extent to which synergistic training methodologies (e.g., simulation based exercises and advanced technologies) can be disseminated are influenced also by resource disparities across institutions. With well-funded programs, state of the art simulation labs, and faculty

development initiatives, technical as well as interpersonal skill training can be integrated in a seamless fashion. By comparison, under resourced institutions have no access to such tools and must rely on didactic traditional methods that are less efficient in teaching real world communication skills. But these disparities can, and should, be addressed. Partnerships like institutional resource-sharing or virtual platforms that are open access can democratize access to high quality training materials [67]. For example, cloud based simulation platforms would allow students from multiple institutions to participate in common standardized training exercises, ensuring that the student will learn the same material regardless of where they attend school.

A second challenge is faculty readiness and willingness to shift curricula as they evolve [68]. Teaching these communication and psychological strategies may prove difficult for faculty with primarily technical backgrounds, who may require targeted professional development to be effective teachers of these strategies. Educators can be empowered to adopt these changes by utilizing workshops, peer mentoring, and continuous learning opportunities, allowing them to fine tune their teaching practices to these ever changing standards relevant to today's day and age [69].

Moreover, training approaches must be tailored to suit local needs in view of the variety in cultural and regional context. For instance, one set of communication strategies may not hold so much meaning for a patient in one cultural setting yet have tremendous meaning in another. Institutions can create inclusive and effective education models when institutions adapt their training to add local patient demographics; foster a global exchange of best practices.

Strategies for enhancing communication skills

However, various ways are available for improving communication skills training in the orthodontic education. An approach that shows promise is bringing in collaboration, where orthodontic programs work alongside psychologists, speech therapists and healthcare specific clinical trainers to provide the communication and psychological strategies from their perspective [12]. Collaboration with psychologists, speech therapists, and communication experts would help orthodontic programs to create multi-faceted training modules that would train students in how to communicate effectively with the patients and managing anxiety.

Role playing and patient simulations are another tool. These methods let students practice real world communication scenarios in a safe known environment. For example,

students might role play the role of an intake interview and role play how they are going to explain the treatment plan or answer what their concerns are or to manage a patient who is difficult to work with. The research shows that role playing improves students' communication skills significantly, as students get quick feedback on their performance [25]. These exercises help students to develop empathy, active listening and problem solving skills needed to stimulate positive interactions with patients.

Furthermore, learning is reinforced in the feedback sessions following role playing or simulation exercises. Feedback that is constructive is useful because it helps students to identify where they need to improve so that they can refine skill and feel more confident in their communication abilities with patients [70]. Furthermore, these feedback sessions could be built into regular clinical case discussions or patient interaction reviews giving students on going opportunities to hone their communication skills.

Lastly, communication skills cannot be addressed as a standalone subject which forces the inclusion of them in the education of all professions in their respective disciplines or faculties. Communication training can be embedded throughout the orthodontic program so that students can practice and refine skills repeatedly as they are doing clinical work. For example, communication skills could be added to patient case presentations, treatment planning discussions and ethics courses. The importance of communication will be reinforced with its continuous exposure and students would develop this skill in a complementary manner to their technical expertise [12].

D. Bridging the gap between clinical and interpersonal skills

The need for integration

The curriculum for orthodontic education should combine clinical expertise with interpersonal abilities for students to meet both patient expectations and behavioral requirements before performing technical dental procedures. Traditional orthodontic instruction based on diagnosis and treatment procedures ignores the fundamental importance that patient compliance depends on realistic expectation guidance and empathetic communication abilities by the orthodontist [1,7,26]. Results from this dissertation prove that orthodontists must develop comprehensive skills to combine technical competence and communication abilities which builds patient trust and adherence.

Patient-centered care practices that focuses on patient wants and psychological factors together with personal values necessitates a unification of medical competencies with communication abilities [71]. The failure to manage patients' anticipated pain together with expected discomfort levels along with therapy length results in emotional distress that produces behavioral resistance to their treatment. Effective expectation management surpasses basic technical skills because it needs the combination of empathy and listening proficiency and the skill to handle delicate talks regarding discomfort and aesthetic changes [4]. Patient outcomes demonstrate that both motivational interviewing and pre-procedural counseling foster patient confidence and adherence leading to increased adherence so their training needs to become standard in orthodontic education.

From a technical perspective the patient training system must adjust to what a patient realistically expects. For procedural satisfaction, patients must experience treatment better than what was described in their consent processes. Research findings indicate patients demonstrate better satisfaction levels and better follow doctor's treatment plans after they encounter easier procedures than their initial discomfort predictions. Patient-centered training of orthodontists through proper procedures improves treatment trust and patient cooperation [71]. By combining hands-on training with communication skill development, orthodontic education ensures that students not only convey treatment expectations effectively but also perform procedures in a way that supports patient confidence and satisfaction.

This integrated approach aligns with broader trends in holistic healthcare, where practitioners are expected to treat patients as individuals rather than simply cases to be solved. In orthodontics, this is particularly critical given the long treatment durations, requiring sustained engagement and trust over months or years [71]. When communication and technical training are fused into a single, cohesive educational model, orthodontic programs can better prepare students to interact with patients on physical, emotional, and psychological levels, ultimately leading to higher patient adherence, improved clinical outcomes, and greater professional fulfillment for orthodontists.

Synergies between simulation and communication training

Combining simulation based training and communication skills development is a unique opportunity for enhancing orthodontics education. The two literature reviews used as the basis of this dissertation highlight that simulation tools, VR simulations and 3D models in particular, are instrumental to the development of students' technical skills; but these tools go

beyond simply allowing for practice of clinical procedure, they can also be used for practicing communication and psychological strategies in patient care [1,7].

Part of the major benefits of simulations for both technical and communicative training purposes is the fact that they can repatriate real world scenarios in a controlled environment. VR systems can be useful for simulation of patient interaction in a safe space where students can learn not only diagnostic skills, but also how to communicate with orthodontic patients and respond to commonly encountered obstacles in orthodontic care, as pointed out by Chen et al. and Lin-na et al. [38,39]. For instance, students could use simulations to practice giving explanations to a virtual patient on complex treatment plans, such as ways to manage the patient's concern regarding cost, time, or expected outcomes.

The use of these simulations helps students achieve better treatment adherence by educating them to clearly define patient expectations during early stages of patient care. Student development of empathetic communication and problem-solving skills happens through role-playing simulations that let students become both orthodontist and patient [51]. The exercises proved most helpful for student preparation in dealing with intense patient encounters regarding treatment pain and appearance worries along with treatment change stress. The combination of structured nonadherence conversations and treatment anxiety and miscommunication scenarios enables students to perform simulated dialogues which help them learn refined explanation methods along with reassurance techniques and patient compliance support through safe practice scenarios.

An integrated training model should include structured modules that alternate between technical procedures and patient-centered communication workshops. This approach can help make sure that students not only refine their clinical skills but also build confidence in handling complex patient interactions. For example, after completing a technical session on bracket placement, students could engage in a communication module where they practice explaining treatment plans to a simulated patient in a clear and compassionate manner. By blending procedural skill development with communication practice, orthodontic education can better equip students to manage both the technical and psychological aspects of patient care, ensuring more positive treatment experiences and improved adherence.

Integrating communication training with advanced technologies

The use of modern technology in orthodontic education has largely been described in the context of acquiring clinical skills. However, these tools also hold significant potential for

transforming psychological and communication strategies, particularly in managing patient expectations, improving adherence, and reducing treatment-related anxiety [38,72]. VR simulations of patient interactions are increasingly incorporated into curricula to help students practice delivering complex treatment information, responding to patient concerns, and managing emotional reactions in a controlled, low-risk setting [7,38].

Trainees can role-play challenging scenarios, such as managing noncompliance, explaining treatment risks, or adjusting patient expectations about discomfort and duration [4]. Interactive virtual patient modules provide real-time feedback on both verbal and non-verbal communication skills, allowing students to refine how they convey empathy, clarity, and reassurance [38]. Additionally, artificial intelligence-driven platforms analyze communication effectiveness, offering targeted feedback on areas such as tone, clarity, and patient engagement [43]. These AI-driven systems help identify gaps in how information is conveyed, ensuring that orthodontists can align their explanations with patient concerns to improve trust and compliance.

Additionally, digital tools in the form of 3D treatment visualizations have the potential to add to psychological strategy by allowing patients to better have a grasp on their treatment plans. With these tools, the clinicians bring precision of clinical communication gap and aid better communication between patient and clinician, which help to reduce anxiety and build trust. We are beginning to see more and more educators integrate these kinds of technologies into the orthodontic curriculum, because they understand how they can not only make the teaching of technical skills better but also help to develop the interpersonal talents most relevant to patient outcomes.

As orthodontic education evolves, educators increasingly recognize that advanced technologies can improve not only technical training but also the interpersonal skills most relevant to patient outcomes. By integrating these digital tools into orthodontic curricula, students can develop both procedural expertise and the communication abilities necessary to navigate patient concerns effectively, ensuring that treatment expectations are both realistic and well-managed.

Implementation challenges

Multiple barriers limit the successful introduction of combined technical and communication education for orthodontic professionals in training programs. A basic challenge arises because both patients and providers frequently ignore how patient expectations influence

their level of compliance [4]. Patients commonly begin treatment with false expectations about the amount of pain they will feel and the level of procedure difficulty that leads to treatment anxiety and reluctance to continue treatment along with non-compliance [73]. The absence of proper psychological communication training for orthodontists creates challenges in addressing false beliefs at initial stages of care thus producing displeasure for clinical professionals and patients. Most orthodontic programs emphasize training in technical aspects rather than interpersonal traits which results in graduating students lacking the necessary competencies for psychological barrier intervention during patient adherence [1,7].

Institutional resistance to integrating psychological and communication training remains a major obstacle. Many faculty members, trained in traditional medical and dental education models, emphasize clinical procedures over patient interaction, contributing to the perception that communication training is secondary or unnecessary [42]. However, patient adherence has been shown to increase when orthodontists effectively communicate treatment expectations, risks, and procedural realities in ways that patients can understand and trust [4]. Resistance among faculty members often stems from a lack of understanding of the link between communication skills, patient compliance, and treatment success, as well as concerns about curricular overload in an already demanding training program [41].

Resource constraints present another significant challenge, particularly in institutions with limited access to simulation-based training tools. The ability to adjust and align patient expectations before treatment begins plays a critical role in ensuring compliance, yet many programs lack access to the technologies that can enhance this process [17]. VR-based training, 3D models, and AI-driven patient simulations provide valuable opportunities for students to practice both technical execution and patient communication in a controlled setting, but financial barriers limit the availability of these resources [7]. Huang et al. highlight that unequal access to these technologies across institutions creates disparities in training quality, with students from well-funded programs gaining a distinct advantage in both procedural and interpersonal skill development [74]. Additionally, training faculty to effectively use these tools and integrate communication strategies requires financial and logistical investment, which some institutions may be reluctant to undertake.

Another major hurdle is the lack of standardized pedagogical methods for teaching communication skills in orthodontics. While structured approaches for clinical procedures are well established, communication training remains inconsistent across programs [1].

Misalignment between patient expectations and actual treatment experiences can negatively affect adherence, yet few orthodontic programs offer structured instruction on expectation-setting, anxiety management, and patient reassurance techniques. Without a consistent, evidence-based approach, orthodontic students may graduate with technical expertise but insufficient skills to build trust, alleviate patient fears, and reinforce compliance.

The successful integration of a dual-focus training model depends heavily on faculty preparedness and institutional support. Effective patient management requires orthodontists to proactively engage with concerns and modify expectations through structured conversations, reinforcing the need for faculty training programs that equip educators with both clinical and psychological teaching strategies. Faculty should receive hands-on training in using VR simulations, typodonts, and interactive digital models, but just as importantly, they should develop expertise in teaching psychological communication techniques, such as pre-procedural counseling, motivational interviewing, and managing treatment-related anxiety.

Beyond faculty development, institutions must also support interdisciplinary collaboration. Training orthodontists to navigate both technical and psychological aspects of treatment requires cooperation between educators, psychologists, communication experts, and experienced clinicians. Universities can partner with technology providers to increase access to simulation tools, ensuring that orthodontic students have consistent, high-quality training in both technical execution and patient-centered communication.

Solutions for successful integration

To successfully integrate technical and interpersonal skills into orthodontic education, targeted curriculum reforms, faculty development, and resource acquisition strategies must be implemented. A key solution is to redesign curricula so that communication and psychological skills receive the same emphasis as technical competencies. Current training gaps in patient communication, expectation management, and psychological strategies must be identified, and new educational modules should be developed to address these areas [71]. For example, incorporating structured communication workshops into the core curriculum would provide students with formal instruction on patient interaction, expectation-setting, and anxiety management. These workshops could be directly integrated with clinical training, allowing students to practice both procedural execution and patient communication in tandem, ensuring that patient concerns are addressed alongside technical precision.

Furthermore, this integration requires faculty development to be successful. The literature reviews this dissertation is based upon lay special emphasis on the fact that several faculty members may not have been trained adequately enough to teach communication skills properly [75]. Therefore, institutions are able to create faculty development programs that concentrate on communication training as well as simulation tools incorporation into curriculum. Not only would this prepare faculty who will be teaching technical and interpersonal skills, but it would also encourage an atmosphere where communication is looked upon as an element of orthodontic care.

Finally, institutions need to seek external fund sources to solve resource constraints. Orthodontic programs can either partner with technology companies or apply for government grants to secure the resources needed to undertake simulation based training in both clinical and communication contexts. By exploiting existing computation resources, this approach can promote the wider use of advanced simulation technologies and ensure that all students can benefit from high quality learning tools regardless of the resources available to the host institution.

E. Implications for orthodontic education and future directions

Implications for orthodontic practice

The implications of integrating simulation-based training and communication/psychological strategies into orthodontic education are profound. A patient-centered approach is fundamental to achieving successful treatment outcomes, but a critical barrier remains: many patients enter treatment with unrealistic expectations about pain, discomfort, and procedural complexity, which directly impacts adherence and satisfaction. Research highlights that orthodontic education must evolve to prepare clinicians not only to execute procedures with precision but also to effectively communicate and manage patient expectations [1,7]. A more holistic approach that combines clinical and interpersonal training ensures that orthodontists are equipped to align patient perceptions with treatment realities, ultimately improving both technical outcomes and the patient experience.

One of the most significant implications of this integrated training model is its potential to enhance patient compliance and long-term treatment adherence. When patients receive clear, psychologically informed explanations of their treatment process, they are more likely to trust their provider, follow recommendations, and remain engaged throughout lengthy orthodontic procedures. Studies indicate that motivational interviewing and empathy-based communication

approaches help orthodontists proactively address patient anxieties, reset unrealistic expectations, and reinforce adherence to treatment protocols [4]. By incorporating expectation management training into orthodontic education, future practitioners will be better prepared to navigate difficult conversations about pain perception, procedural complexity, and treatment duration, ensuring greater patient cooperation.

The potential for improved patient satisfaction extends beyond just adherence. As orthodontic treatments become increasingly individualized and technologically advanced, the ability to communicate complex procedures and treatment plans is critical [76]. Patients who understand their treatment goals and procedural steps are less likely to experience frustration or disappointment, making pre-procedural communication a crucial determinant of both clinical and emotional treatment success. Additionally, the rise of virtual consultations has further amplified the need for orthodontists to develop strong communication skills to ensure that patients receive accurate, expectation-aligned information even before setting foot in a clinic [4].

Possible long-term implications

The incorporation of communication and psychological strategies into orthodontic education has far-reaching implications for long-term clinical outcomes and patient experiences. Beyond improving immediate patient satisfaction and adherence, these competencies can significantly enhance the overall quality of orthodontic care by ensuring that patients remain engaged and committed throughout the entire treatment cycle [1,7]. Since most orthodontic treatments span several months to years, sustained patient cooperation is essential for achieving successful results and minimizing complications caused by noncompliance. When orthodontists are trained to recognize and manage patient expectations from the outset, they can proactively address misconceptions about treatment duration, discomfort, and procedural complexity, ultimately reducing treatment interruptions, nonadherence, and dropout rates.

Empathy-driven communication and expectation-setting play a critical role in fostering long-term patient engagement. Patients who feel heard, understood, and supported are more likely to follow hygiene protocols, wear aligners consistently, and attend scheduled appointments [77]. For example, a patient who believes that aligner compliance is crucial for their treatment success—because an orthodontist has effectively communicated this expectation—will be more likely to adhere to prescribed wear times, minimizing the need for

extended therapy or corrective interventions. By contrast, when expectations are not properly managed, frustration and disengagement increase, leading to prolonged treatment durations and diminished outcomes.

Beyond individual patient interactions, psychological strategies such as anxiety management and motivational interviewing contribute to better emotional well-being throughout treatment. Patients who experience reduced anxiety regarding their procedures report higher satisfaction levels, are more likely to remain engaged, and perceive their overall treatment experience more positively [1]. These positive experiences extend beyond the individual patient, influencing the reputation of orthodontic practices. Satisfied patients are more likely to recommend their providers, generating word-of-mouth referrals and increasing patient retention over time.

From an organizational perspective, integrating interpersonal and psychological training into orthodontic education offers long-term financial and operational benefits. Graduates who receive holistic patient care training are better equipped to address the needs of diverse patient populations, reducing disparities in orthodontic access and treatment outcomes [78]. Additionally, a workforce trained in patient-centered care minimizes the likelihood of treatment delays, unnecessary complications, and patient dissatisfaction, ultimately lowering the costs associated with corrective interventions and patient attrition.

Further longitudinal research is needed to quantify the long-term benefits of integrating communication and psychological strategies into orthodontic education. Studies tracking treatment adherence, patient satisfaction, and clinical outcomes over extended periods could provide stronger evidence supporting the expansion of these competencies within orthodontic curricula. By systematically evaluating these long-term impacts, orthodontic programs can ensure that future training models align with the evolving demands of patient-centered care and clinical excellence.

Global perspectives on orthodontic education

Because orthodontic education functions in an increasingly globalized construct, delivery of evidence based treatment must be adaptable to a wide array of cultural and regional contexts. However, existing research underscores the need for simulating equipment within integration of orthodontic programs of simulation learning, communication training, and psychological skill development. These practices are based on solid empirical evidence;

however, additional positive lessons can be drawn from international and regional variations in educational practice.

For instance, the implementation of simulation based learning tools like virtual reality systems and digital typodonts has been quite successful in increasing clinical preparedness and technical proficiency, as already established. These tools may be used; however, they are often impractical to implement in resource limited settings. From the experience in regions that have adopted these technologies, such as low cost VR platforms or collaborative resource sharing among institutions, we are able to learn from practical solutions. By adhering to global best practices as well as offering these advanced tools, all approaches provide equity in the orthodontic education space.

Patient centered care models which focus on motivational interviewing and empathetic communication require similar needs in orthodontic training. Alongside these methods is strong evidence that they can be applied as long as the cultural variation in patient expectations, communications style and psychological reaction to orthodontic treatment is taken into consideration. Research from a variety of cultural settings provides useful insights into how we can strongly adapt these practices without losing their effectiveness. For instance, in regions of the world in diverse cultural settings, culturally informed communication strategies may contribute to better adherence of patients and to building trust with clinicians, where they are different from the Western communication model [79].

In addition, some orthodontic education is also dependent on international collaborations. The exchange of best practices and standardized benchmarks for training are developed in partnerships between academic institutions across different countries [80]. Such collaborations can help closer the integration gap while providing for regional specificity. For instance, a global consortium on orthodontic education could set guidelines to integrate the communication and psychology training into its regular curricula, on the basis of the success of such cases from several parts of the globe.

Furthermore, the global perspective highlights the importance of preparing students to work in diverse healthcare settings. By exposing students to the best international practices and evidence-based strategies, orthodontic programs can better equip future practitioners to navigate the complexities of modern patient care. This includes understanding the psychosocial dimensions of treatment, addressing anxiety and adherence challenges, and delivering culturally sensitive care.

Ethical implications of an enhanced orthodontic curriculum

Orthodontic education must not only prioritize clinical and interpersonal skills but also integrate ethical principles that govern patient care. Expanding the curriculum to include communication and psychological training allows for more consideration for ethical regards in which practitioners are schooled in the integration of communication and compassion in complex patient interactions. Good communication leads to effective consent and shared clinical decisions — the moral requirement of patient centered care [1]. As orthodontists work to conduct clear and respectful discussions, whilst being empathetic, they give patients the ability to make sound choices about their treatment, which is essential to ethical practice.

Beyond just ethical care, psychological training provides the ability to manage patient anxiety and responsibility all within their care. Orthodontic treatments are often long, have aesthetic consequences, and increase emotional vulnerability. The concerns about these are taken care of by empathy trained and psychologically trained practitioners without promising them false hope and undue stress. This approach not only supports patient well-being but also underscores the ethical principle of nonmaleficence, ensuring that care minimizes harm while fostering trust [81].

Ethical preparedness also depends upon simulation based training. Both allow students to rehearse responses to ethical dilemmas, e.g., in response to nonadherence or when talking about financial constraints. This develops roles of the future orthodontists to who can make ethically sound decisions in real life situations and of course of they have to be accountable and responsible for their own actions. But there are ethical questions with integrating all that advanced technology. With increasing course offerings, institutions must guarantee all students access to simulation tools with equitable quality, so that students from less resource rich programs are not disadvantaged. Moreover, as technology enables technical skill, care must be taken so that the human connection upon which ethical patient care depends remains. By injecting ethics in the communication, psychological, and simulation training, the curriculum has served to improve clinical outcomes while simultaneously reinforcing the commitment to providing respectful, dignified, fair treatment of patients.

Recommendations for future research

Although the existing literature provides significant insights, it also reveals key gaps that must be addressed. One of the most pressing areas for future research is investigating the long-term impact of communication training on patient expectations, compliance, and overall

treatment success. Current studies primarily focus on short-term outcomes, such as immediate patient satisfaction, adherence to early treatment protocols, and engagement in decision-making [1]. However, orthodontic treatment often spans months or years, and longitudinal studies are needed to examine whether expectation-setting strategies at the start of treatment continue to influence adherence, patient retention, and clinical outcomes over time. For instance, further research could explore how motivational interviewing and empathy-based training help patients adjust their expectations at different stages of treatment—from the initial consultation to active orthodontic treatment and long-term retention [72].

Another critical area for future research is the integration of communication skills with simulation-based technical training. While simulation tools have been widely studied in the context of technical skills development, there is limited research on their effectiveness in training orthodontists to manage patient expectations, reduce anxiety, and navigate difficult conversations [1,7]. For example, future studies should evaluate whether virtual patients, role-playing exercises, and AI-driven communication simulations enhance students' ability to guide patients through concerns about treatment discomfort, cost, and adherence challenges. Further research should also develop and test new curriculum models that integrate both technical execution and psychological communication training into a cohesive learning framework [82].

Additionally, cost-effectiveness studies are needed to quantify the economic impact of simulation and communication training in orthodontic education. The high cost of implementing VR-based tools and digital patient simulations remains a major barrier, particularly for institutions with limited financial resources [7]. Future research should explore affordable alternatives to high-cost simulation technologies and investigate potential funding strategies, including industry partnerships and grant programs, to expand access. Importantly, studies should also evaluate the return on investment of these training tools by measuring their impact on student performance, patient adherence, and clinical efficiency. Reducing treatment delays caused by noncompliance could significantly lower overall healthcare costs, reinforcing the case for widespread adoption of expectation-management training in orthodontic programs.

Finally, future studies should examine the global applicability of communication and simulation training in orthodontics. Patient expectations vary across cultural contexts, and the effectiveness of communication strategies may depend on cultural attitudes toward medical decision-making, trust in healthcare providers, and perceptions of pain and treatment difficulty. Research should investigate how different populations interpret orthodontic treatment

expectations and determine whether communication strategies and simulation-based training require adaptation to be effective across diverse patient demographics. By exploring culturally responsive approaches, future research can ensure that interpersonal skill training in orthodontics remains inclusive and adaptable for global education standards.

Limitations

A primary concern is the heterogeneity of study designs across the included research. The reviews examined a variety of methodologies, including quasi-experimental designs, observational studies, RCTs, and cross-sectional surveys. However, the variability in study designs, populations, and outcome measures introduces methodological inconsistency, making it difficult to draw universally applicable conclusions for orthodontic programs worldwide. Because some studies assessed simulation tools primarily in terms of technical proficiency, while others focused on student or patient-reported communication improvements, there remains a lack of cohesive, standardized evaluation metrics across studies.

Another limitation is the underrepresentation of long-term studies examining the impact of communication training on patient adherence and treatment success. While many studies assess short-term outcomes, such as immediate patient satisfaction or student learning following exposure to communication and simulation training, there is limited research on how expectation-setting interventions influence patient compliance over extended orthodontic treatment cycles. Given that orthodontic care often spans years, future research must evaluate whether early interventions to align patient expectations result in sustained adherence to treatment protocols, fewer mid-treatment dropouts, and improved long-term clinical outcomes.

Additionally, many of the reviewed studies relied on self-reported data, which presents inherent risks of bias and overestimation of satisfaction or adherence. Studies measuring patient compliance, treatment satisfaction, or student confidence in communication skills often used subjective surveys, which may be affected by social desirability bias or participant expectations. For instance, patients might overstate satisfaction levels due to a desire to please researchers or their orthodontist, and students may overestimate their communication proficiency immediately after training sessions without demonstrating sustained improvement in real-world clinical settings. Future research should incorporate objective adherence measures, such as treatment completion rates, appointment attendance, and clinical outcomes, to provide a more accurate assessment of training effectiveness.

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Furthermore, one key limitation is the difficulty of isolating the effects of communication training from other external factors influencing patient adherence. Compliance with orthodontic treatment is multifactorial, influenced not only by clinician-patient communication but also by socioeconomic status, prior healthcare experiences, cultural perceptions of orthodontics, and personal motivation. Because expectation-setting strategies are often integrated into broader patient interactions, it remains challenging to determine the specific impact of communication techniques alone on treatment adherence. Future research should explore how expectation management interacts with these external factors to ensure that training models are tailored to diverse patient populations.

Finally, while this dissertation synthesizes findings from three interrelated areas of orthodontic education, it is a secondary review that does not include original empirical research. Although based on systematic reviews, the dissertation does not present firsthand data on how integrating expectation management, communication training, and simulation-based learning impacts real-world patient outcomes. Additionally, the scope of this review focused exclusively on these training methods, without addressing other critical aspects of orthodontic education, such as interdisciplinary collaboration, ethics, or global variations in training methodologies. Expanding the scope further would have diverted focus from the central objective of evaluating technical and interpersonal skill integration in orthodontic education.

IX. CONCLUSIONS

This dissertation has synthesized findings from three interrelated areas of orthodontic education—patient expectation management, simulation-based training, and communication/psychological strategies—to establish a comprehensive framework for training orthodontists in both technical proficiency and interpersonal competence. While technical skills remain the foundation of orthodontic education, research demonstrates that failure to manage patient expectations early in treatment can lead to noncompliance, dissatisfaction, and extended treatment durations, reinforcing the need for a curriculum that integrates expectation-setting alongside procedural skill development. By addressing patient misconceptions, employing psychological communication strategies, and incorporating simulation-based learning, orthodontic programs can better prepare students to navigate the complexities of real-world patient care, improve adherence, and enhance treatment satisfaction. However, significant challenges remain, including the high cost of advanced simulation tools, limitations in faculty training, and institutional resistance to shifting from traditional models that

emphasize direct patient care over structured interpersonal skill development. Many programs still prioritize technical training over communication education, limiting students' ability to effectively engage with patients and manage expectations in ways that improve treatment compliance. Additionally, while short-term research has demonstrated the effectiveness of these training strategies, longitudinal studies are needed to examine how expectation-setting techniques influence patient adherence and clinical outcomes over multi-year orthodontic treatment cycles. Despite these challenges, this dissertation underscores the critical need for an integrated educational approach that merges technical expertise with patient-centered communication, ensuring that future practitioners can build trust, reduce anxiety, and foster long-term compliance. By fostering an educational environment that values both clinical precision and psychological competencies, orthodontic programs can better equip students to meet the growing expectations of modern patients, ultimately leading to improved treatment experiences, greater patient satisfaction, and enhanced clinical outcomes.

X. ACKNOWLEDGEMENTS

XI.REFERENCES

1. Baxmann, M.; Baráth, Z.; Kárpáti, K. The Role of Psychology and Communication Skills in Orthodontic Practice: A Systematic Review. *BMC Medical Education* **2024**, *24*, 1472, doi:10.1186/s12909-024-06451-6.
2. Kusaibati, A.M.; Sultan, K.; Hajeer, M.Y.; Burhan, A.S.; Alam, M.K. Adult Patient Expectations and Satisfaction: Can They Be Influenced by Viewing the Three-Dimensional Predicted Outcome before Fixed Orthodontic Treatment of Dental Crowding? *Journal of the World Federation of Orthodontists* **2023**, *12*, 269–279, doi:10.1016/j.ejwf.2023.08.005.
3. Raj, S.P.; Priyadharshni, R.; Rajeswari, M.R.C.; Karthick, B.P.; Kalaimani, G. Assessment of Influence of Internet toward Dental Treatment: A Cross-Sectional Study. *Journal of Dental Research and Review* **2023**, *10*, 234, doi:10.4103/jdrr.jdrr_88_23.
4. Büyükbayraktar, Z.Ç.; Doruk, C. Dental Anxiety and Fear Levels, Patient Satisfaction, and Quality of Life in Patients Undergoing Orthodontic Treatment: Is There a Relationship? *Turk J Orthod* **2021**, *34*, 234–241, doi:10.5152/TurkJOrthod.2021.21177.
5. Silva, I.; Miranda, F.; Lauris, J.R.P.; Garib, D. Soft Skills in Orthodontics: An Analysis in Residents and Experienced Professionals. *Dental Press J Orthod* **2024**, *29*, e242370, doi:10.1590/2177-6709.29.2.e242370.oar.
6. Mahdavifard, H.; Noorollahian, S.; Omid, A.; Yamani, N. What Competencies Does an Orthodontic Postgraduate Need? *BMC Med Educ* **2024**, *24*, 1461, doi:10.1186/s12909-024-06475-y.
7. Baxmann, M.; Baráth, Z.; Kárpáti, K. Efficacy of Typodont and Simulation Training in Orthodontic Education: A Systematic Review. *BMC Medical Education* **2024**, *24*, 1443, doi:10.1186/s12909-024-06425-8.
8. Mehta, S.; Kesterke, M.J.; Glenn, G.; Tadlock, L. Incorporating Clinical Innovations into Teaching Curriculum in Orthodontic Residency Programs: Checklists and Roadmaps. *Seminars in Orthodontics* **2024**, *30*, 429–435, doi:10.1053/j.sodo.2024.05.003.
9. Pandey, R.; Kamble, R.; Kanani, H. Revolutionizing Smiles: Advancing Orthodontics Through Digital Innovation. *Cureus* **2024**, *16*, e64086, doi:10.7759/cureus.64086.
10. Ticku, S.; Nath, S.; Ramesh, N.; Riedy, C.A. Attitudes toward Adolescent Mental Health Screening in a Dental Setting: A Mixed-Methods Study. *JDR Clinical & Translational Research* **2024**, *9*, 70S-87S, doi:10.1177/23800844241273775.
11. Trakyali, G.; Işik-Ozdemir, F.; Tunaboylu-Ikiz, T.; Pirim, B.; Elif Yavuz, A. Anxiety among Adolescents and Its Affect on Orthodontic Compliance. *Journal of Indian Society of Pedodontics and Preventive Dentistry* **2009**, *27*, 205, doi:10.4103/0970-4388.57654.
12. Chiang, Y.-C.; Wu, F.; Ko, S.-H. Effective Patient–Dentist Communication with a Simulation System for Orthodontics. *Healthcare* **2023**, *11*, 1433, doi:10.3390/healthcare11101433.
13. Prasad Mandava, M.D.S. Burnout in Orthodontists: A Comprehensive Review of Existing Literature. *Journal of Chemical Health Risks* **2024**, *14*, 3220–3235, doi:10.52783/jchr.v14.i2.4164.
14. Soni, S.; Mangla, C.; Pal, T.; Kaur, S. Challenges in Orthodontic Practice - Orthodontists' Perspective. *Journal of Chemical Health Risks* **2024**, *14*, 74–82.
15. Ferlias, N.; Michelotti, A.; Stoustrup, P. Patient Safety in Orthodontic Care: A Scoping Literature Review with Proposal for Terminology and Future Research Agenda. *BMC Oral Health* **2024**, *24*, 702, doi:10.1186/s12903-024-04375-7.

16. Mahdavifard, H.; Noorollahian, S.; Omid, A.; Yamani, N. What Competencies Does an Orthodontic Postgraduate Need? *BMC Med Educ* **2024**, *24*, 1461, doi:10.1186/s12909-024-06475-y.

17. Sipiyaruk, K.; Kaewsirirat, P.; Santiwong, P. Technology-Enhanced Simulation-Based Learning in Orthodontic Education: A Scoping Review. *Dental Press Journal of Orthodontics* **2023**, *28*, e2321354, doi:10.1590/2177-6709.28.3.e2321354.oar.

18. Galang-Boquiren, M.T.; Katebi, N.; Hong, C.; Lipp, M. Predoctoral Orthodontic Education in the United States: Challenges and Opportunities for Generation Z Learners. *Seminars in Orthodontics* **2024**, *30*, 409–412, doi:10.1053/j.sodo.2024.04.008.

19. Imani, M.M.; Jalali, A.; Dinmohammadi, M.; Nouri, P. The Effect of Orthodontic Intervention on Mental Health and Body Image. *Open Access Maced J Med Sci* **2018**, *6*, 1132–1137, doi:10.3889/oamjms.2018.243.

20. Stonehouse-Smith, D.; Pandis, N.; Bister, D.; Seehra, J. Clinical Communication in Orthodontics: Any Questions? *J Orthod* **2022**, *49*, 448–456, doi:10.1177/14653125221084314.

21. Tian, X.; Li, Y.; Deng, L.; Han, W.; Pu, D.; Han, X.; Du, S.; Deng, W. Anxiety and Depression Mediate the Relationship between Digestive Tract Conditions and Oral Health-Related Quality of Life in Orthodontic Patients. *Front. Psychol.* **2022**, *13*, doi:10.3389/fpsyg.2022.873983.

22. John, D.; Raveendranadhan, S. P22 - Trust between Dental Professionals and Patients: A Scoping Review: Presenter(s): Siyang Yuan, University of Dundee, United Kingdom. *Patient Education and Counseling* **2023**, *109*, 51, doi:10.1016/j.pec.2022.10.124.

23. Tiwari, T.; Maliq, N.N.; Rai, N.; Holtzmann, J.; Yates, L.; Diep, V.; Tranby, E.P.; Frantsve-Hawley, J. Evaluating Trust in the Patient–Dentist Relationship: A Mixed-Method Study. *JDR Clinical & Translational Research* **2023**, *8*, 287–298, doi:10.1177/23800844221087592.

24. Shelswell, J.; Patel, V.A.; Barber, S. The Effectiveness of Interventions to Increase Patient Involvement in Decision-Making in Orthodontics: A Systematic Review. *J Orthod* **2022**, *49*, 129–142, doi:10.1177/14653125211048202.

25. Abdel-Wahed, N.; Badahdah, A.; Qutob, A.F.; Bahanan, L.; Bukhary, S.M.N. The Effectiveness of Integrating Role Play into Case-Based Learning in Dental Education: Enhancing Critical Thinking and Teamwork Skills. *BMC Medical Education* **2024**, *24*, 1531, doi:10.1186/s12909-024-06550-4.

26. Baxmann, M.; McDonald, F.; Bourauel, C.; Jäger, A. Expectations, Acceptance, and Preferences Regarding Microimplant Treatment in Orthodontic Patients: A Randomized Controlled Trial. *American Journal of Orthodontics and Dentofacial Orthopedics* **2010**, *138*, 250.e1-250.e10, doi:10.1016/j.ajodo.2010.03.023.

27. Cochrane Bias RoB 2: A Revised Cochrane Risk-of-Bias Tool for Randomized Trials Available online: https://methods.cochrane.org/bias/resources/rob-2-revised-cochrane-risk-bias-tool-randomized-trials (accessed on 29 December 2024).

28. Wells, G.A.; O'Connell, D.; Peterson, J.; Welch, V.; Losos, M.; Tugwell, P. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomised Studies in Meta-Analyses Available online: https://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed on 29 December 2024).

29. Cochrane Training GRADE Approach Available online: https://training.cochrane.org/grade-approach.

30. Ho, J.C.Y.; Chai, H.H.; Lo, E.C.M.; Huang, M.Z.; Chu, C.H. Strategies for Effective Dentist-Patient Communication: A Literature Review. *Patient Prefer Adherence* **2024**, *18*, 1385–1394, doi:10.2147/PPA.S465221.

31. Pilgrim, C.; Catunda, R.; Major, P.; Perez-Garcia, A.; Flores-Mir, C. Patient-Provider Communication during Consultations for Elective Dental Procedures: A Scoping Review. *American Journal of Orthodontics and Dentofacial Orthopedics* **2024**, *166*, 413-422.e6, doi:10.1016/j.ajodo.2024.07.014.

32. van der Bie, R.M.; Bos, A.; Bruers, J.J.M.; Jonkman, R.E.G. Patient Adherence in Orthodontics: A Scoping Review. *BDJ Open* **2024**, *10*, 1–9, doi:10.1038/s41405-024-00235-2.

33. Bradley, E.; Shelton, A.; Hodge, T.; Morris, D.; Bekker, H.; Fletcher, S.; Barber, S. Patient-Reported Experience and Outcomes from Orthodontic Treatment. *J Orthod* **2020**, *47*, 107–115, doi:10.1177/1465312520904377.

34. Talic, N.F. Adverse Effects of Orthodontic Treatment: A Clinical Perspective. *Saudi Dent J* **2011**, *23*, 55–59, doi:10.1016/j.sdentj.2011.01.003.

35. Doll, G.M.; Zentner, A.; Klages, U.; Sergl, H.G. Relationship between Patient Discomfort, Appliance Acceptance and Compliance in Orthodontic Therapy. *J Orofac Orthop* **2000**, *61*, 398–413, doi:10.1007/pl00001908.

36. Oliver, G.R.; Lynch, C.D.; Fleming, P.S. What I Wish I'd Learned as an Orthodontic Trainee: An Online Survey of British Orthodontic Society Members Concerning Postgraduate Training Experiences. *J Orthod* **2020**, *47*, 116–128, doi:10.1177/1465312520904367.

37. Huang, Y.; Cheng, X.; Chan, U.; Zheng, L.; Hu, Y.; Sun, Y.; Lai, P.; Dai, J.; Yang, X. Virtual Reality Approach for Orthodontic Education at School of Stomatology, Jinan University. *Journal of Dental Education* **2022**, *86*, 1025–1035, doi:10.1002/jdd.12915.

38. Chen, D.; Liu, X.; Liu, Y.; Wang, X.; Zheng, J.; Wu, L. Virtual Reality Used in Undergraduate Orthodontic Education. *European Journal of Dental Education* **2023**, 1–9, doi:10.1111/eje.12968.

39. Lin-na, W.; Wei-wei, C.; Li-hua, H.; Chun-yan, L.; Wen-sheng, M.; Ye, L.; De-chao, Z.; Yang, L.; Xiao-lei, G.; Yan, H. Application of Scenario Simulation Combined Case Teaching Method in the Improvement of Doctor-Patient Communication Ability of Orthodontic Graduate Students. *High. Educ. Res.* **2023**, *9*, 242–246, doi:10.11648/j.her.20230806.15.

40. Balos Tuncer, B.; Sokmen, T.; Celik, B.; Tortop, T. Perception of Dental Students towards Case-Based Orthodontic Education. *J Orofac Orthop* **2022**, *83*, 96–101, doi:10.1007/s00056-021-00325-y.

41. Kaggal Lakshmana Rao, G.; P Iskandar, Y.H.; Mokhtar, N. Developing Consensus in Identifying Challenges of Undergraduate Orthodontic Education in Malaysian Public Universities Using E-Delphi. *European Journal of Dental Education* **2020**, *24*, 590–600, doi:10.1111/eje.12540.

42. Maresca, C.; Barrero, C.; Duggan, D.; Platin, E.; Rivera, E.; Hannum, W.; Petrola, F. Utilization of Blended Learning to Teach Preclinical Endodontics. *Journal of Dental Education* **2014**, *78*, 1194–1204, doi:10.1002/j.0022-0337.2014.78.8.tb05791.x.

43. Liu, L.; Yuan, S.; Zhang, W.; Wang, Z.; Zhao, C.; Pan, Y.; Yan, B.; Wang, L. Development and Assessment of an Online Virtual Orthodontic Curriculum. *Journal of Dental Education* **2022**, *86*, 509–516, doi:10.1002/jdd.12825.

44. Bajwa, J.; Munir, U.; Nori, A.; Williams, B. Artificial Intelligence in Healthcare: Transforming the Practice of Medicine. *Future Healthc J* **2021**, *8*, e188–e194, doi:10.7861/fhj.2021-0095.

45. Alowais, S.A.; Alghamdi, S.S.; Alsuhebany, N.; Alqahtani, T.; Alshaya, A.I.; Almohareb, S.N.; Aldairem, A.; Alrashed, M.; Bin Saleh, K.; Badreldin, H.A.; et al. Revolutionizing Healthcare: The Role of Artificial Intelligence in Clinical Practice. *BMC Medical Education* **2023**, *23*, 689, doi:10.1186/s12909-023-04698-z.

46. Dave, M.; Patel, N. Artificial Intelligence in Healthcare and Education. *Br Dent J* **2023**, *234*, 761–764, doi:10.1038/s41415-023-5845-2.

47. Suresh, D.; Aydin, A.; James, S.; Ahmed, K.; Dasgupta, P. The Role of Augmented Reality in Surgical Training: A Systematic Review. *Surg Innov* **2023**, *30*, 366–382, doi:10.1177/15533506221140506.

48. Azher, S.; Mills, A.; He, J.; Hyjazie, T.; Tokuno, J.; Quaiattini, A.; Harley, J.M. Findings Favor Haptics Feedback in Virtual Simulation Surgical Education: An Updated Systematic and Scoping Review. *Surg Innov* **2024**, *31*, 331–341, doi:10.1177/15533506241238263.

49. Aramaki, E.; Wakamiya, S.; Yada, S.; Nakamura, Y. Natural Language Processing: From Bedside to Everywhere. *Yearb Med Inform* **2022**, *31*, 243–253, doi:10.1055/s-0042-1742510.

50. van der Bie, R.M.; Bos, A.; Bruers, J.J.M.; Jonkman, R.E.G. Patient Adherence in Orthodontics: A Scoping Review. *BDJ Open* **2024**, *10*, 1–9, doi:10.1038/s41405-024-00235-2.

51. Al-Silwadi, F.M.; Gill, D.S.; Petrie, A.; Cunningham, S.J. Effect of Social Media in Improving Knowledge among Patients Having Fixed Appliance Orthodontic Treatment: A Single-Center Randomized Controlled Trial. *Am J Orthod Dentofacial Orthop* **2015**, *148*, 231–237, doi:10.1016/j.ajodo.2015.03.029.

52. Bibona, K.; Shroff, B.; Best, A.M.; Lindauer, S.J. Communication Practices and Preferences between Orthodontists and General Dentists. *Angle Orthodontist* **2015**, *85*, 1042–1050.

53. Lauwers, E.D.L.; Vandecasteele, R.; McMahon, M.; De Maesschalck, S.; Willems, S. The Patient Perspective on Diversity-Sensitive Care: A Systematic Review. *International Journal for Equity in Health* **2024**, *23*, 117, doi:10.1186/s12939-024-02189-1.

54. Connor, L.; Dean, J.; McNett, M.; Tydings, D.M.; Shrout, A.; Gorsuch, P.F.; Hole, A.; Moore, L.; Brown, R.; Melnyk, B.M.; et al. Evidence-Based Practice Improves Patient Outcomes and Healthcare System Return on Investment: Findings from a Scoping Review. *Worldviews on Evidence-Based Nursing* **2023**, *20*, 6–15, doi:10.1111/wvn.12621.

55. Guo, Y.; Logan, H.L.; Dodd, V.J.; Muller, K.E.; Marks, J.G.; Riley, J.L. Health Literacy: A Pathway to Better Oral Health. *Am J Public Health* **2014**, *104*, e85–e91, doi:10.2105/AJPH.2014.301930.

56. McCarlie, V.W.; Phillips, M.E.; Price, B.D.; Taylor, P.B.; Eckert, G.J.; Stewart, K.T. Orthodontic and Oral Health Literacy in Adults. *PLoS One* **2022**, *17*, e0273328, doi:10.1371/journal.pone.0273328.

57. Coleman, C. Health Literacy and Clear Communication Best Practices for Telemedicine. *Health Lit Res Pract* **2020**, *4*, e224–e229, doi:10.3928/24748307-20200924-01.

58. Warde, F.; Papadakos, J.; Papadakos, T.; Rodin, D.; Salhia, M.; Giuliani, M. Plain Language Communication as a Priority Competency for Medical Professionals in a Globalized World. *Can Med Educ J* **2018**, *9*, e52–e59.

59. Gellisch, M.; Morosan-Puopolo, G.; Brand-Saberi, B.; Schäfer, T. Adapting to New Challenges in Medical Education: A Three-Step Digitization Approach for Blended Learning. *BMC Medical Education* **2024**, *24*, 585, doi:10.1186/s12909-024-05503-1.

60. Cure, R. Interprofessional Education in an Orthodontic Outreach Training Centre. *Prim Dent J* **2016**, *5*, 63–69, doi:10.1308/205016816820209451.

61. Annamma, L.M.; Varma, S.R.; Abuttayem, H.; Prasad, P.; Azim, S.A.; Odah, R.; George, B.T.; Nair, C.; Karobari, M.I. Current Challenges in Dental Education- a Scoping Review. *BMC Medical Education* **2024**, *24*, 1523, doi:10.1186/s12909-024-06545-1.

62. Qureshi, A.A.; Zehra, T. Simulated Patient's Feedback to Improve Communication Skills of Clerkship Students. *BMC Med Educ* **2020**, *20*, 15, doi:10.1186/s12909-019-1914-2.

63. Lerchenfeldt, S.; Mi, M.; Eng, M. The Utilization of Peer Feedback during Collaborative Learning in Undergraduate Medical Education: A Systematic Review. *BMC Medical Education* **2019**, *19*, 321, doi:10.1186/s12909-019-1755-z.

64. Dewan, P.; Khalil, S.; Gupta, P. Objective Structured Clinical Examination for Teaching and Assessment: Evidence-Based Critique. *Clinical Epidemiology and Global Health* **2024**, *25*, 101477, doi:10.1016/j.cegh.2023.101477.

65. Yan, Z.; Carless, D. Self-Assessment Is about More than Self: The Enabling Role of Feedback Literacy. *Assessment & Evaluation in Higher Education* **2022**, *47*, 1116–1128, doi:10.1080/02602938.2021.2001431.

66. Huang, J.; Yao, Y.; Jiang, J.; Li, C. Effects of Motivational Methods on Oral Hygiene of Orthodontic Patients: A Systematic Review and Meta-Analysis. *Medicine (Baltimore)* **2018**, *97*, e13182, doi:10.1097/MD.0000000000013182.

67. Li, L.; Song, J. An Investigation of the Status and Strategy of College Education Resources Sharing in the Big Data Environment and Countermeasures. *Open Journal of Social Sciences* **2018**, *6*, 192–200, doi:10.4236/jss.2018.610015.

68. Dana, C.; Soffe, B.; Shipley, J.; Licari, F.; Larsen, R.; Plummer, K.; Bybee, S.; Jensen, J. Why Do Faculty Resist Change? *MedEdPublish (2016)* **2021**, *10*, 89, doi:10.15694/mep.2021.000089.1.

69. Price, I.; Regehr, G. Barriers or Costs? Understanding Faculty Resistance to Instructional Changes Associated with Curricular Reform. *Can Med Educ J* **2022**, *13*, 113–115, doi:10.36834/cmej.74041.

70. Le Fouler, A.; Jeanne, S.; Sorel, O.; Brézulier, D. How Effective Are Three Methods of Teaching Oral Hygiene for Adolescents Undergoing Orthodontic Treatment? The MAHO Protocol: An RCT Comparing Visual, Auditory and Kinesthetic Methods. *Trials* **2021**, *22*, 144, doi:10.1186/s13063-021-05093-z.

71. Ho, J.C.Y.; Chai, H.H.; Lo, E.C.M.; Huang, M.Z.; Chu, C.H. Strategies for Effective Dentist-Patient Communication: A Literature Review. *Patient Prefer Adherence* **2024**, *18*, 1385–1394, doi:10.2147/PPA.S465221.

72. Lin-na, W.; Wei-wei, C.; Li-hua, H.; Chun-yan, L.; Wen-sheng, M.; Ye, L.; De-chao, Z.; Yang, L.; Xiao-lei, G.; Yan, H. Application of Scenario Simulation Combined Case Teaching Method in the Improvement of Doctor-Patient Communication Ability of Orthodontic Graduate Students. *High. Educ. Res.* **2023**, *9*, 242–246, doi:10.11648/j.her.20230806.15.

73. Ho, J.C.Y.; Chai, H.H.; Lo, E.C.M.; Huang, M.Z.; Chu, C.H. Strategies for Effective Dentist-Patient Communication: A Literature Review. *Patient Prefer Adherence* **2024**, *18*, 1385–1394, doi:10.2147/PPA.S465221.

74. Huang, Y.; Cheng, X.; Chan, U.; Zheng, L.; Hu, Y.; Sun, Y.; Lai, P.; Dai, J.; Yang, X. Virtual Reality Approach for Orthodontic Education at School of Stomatology, Jinan University. *Journal of Dental Education* **2022**, *86*, 1025–1035, doi:10.1002/jdd.12915.

75. Cserző, D.; Bullock, A.; Cowpe, J.; Bartlett, S. Professionalism in the Dental Practice: Perspectives from Members of the Public, Dentists and Dental Care Professionals. *Br Dent J* **2022**, *232*, 540–544, doi:10.1038/s41415-022-3994-3.

76. Zhao, Y.; Shi, X.; Liu, J.; Huo, R.; Xia, K.; Wang, Y.; Zhu, G.; Lu, W.; Zhang, L.; Meng, Y.; et al. Patients' Perceptions Matter: Risk Communication and Psychosocial Factors in Orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics* **2024**, doi:10.1016/j.ajodo.2024.06.011.

77. Haribhai-Thompson, J.; McBride-Henry, K.; Hales, C.; Rook, H. Understanding of Empathetic Communication in Acute Hospital Settings: A Scoping Review. *BMJ Open* **2022**, *12*, e063375, doi:10.1136/bmjopen-2022-063375.

78. Brooks, L.A.; Manias, E.; Bloomer, M.J. Culturally Sensitive Communication in Healthcare: A Concept Analysis. *Collegian* **2019**, *26*, 383–391, doi:10.1016/j.colegn.2018.09.007.

79. Ogbogu, P.U.; Noroski, L.M.; Arcoleo, K.; Reese, B.D.; Apter, A.J. Methods for Cross-Cultural Communication in Clinic Encounters. *J Allergy Clin Immunol Pract* **2022**, *10*, 893–900, doi:10.1016/j.jaip.2022.01.010.

80. Devine, P.G.; Ash, T.L. Diversity Training Goals, Limitations, and Promise: A Review of the Multidisciplinary Literature. *Annu Rev Psychol* **2022**, *73*, 403–429, doi:10.1146/annurev-psych-060221-122215.

81. Misanjas, M.; Kadhom, Z.M.; Hassan, A.F.A.; Taha, S.S. Ethics In Orthodontic Clinical Practice: (A Review Article). *(Humanities, social and applied sciences) Misan Journal of Academic Studies* **2024**, *23*, 148–154.

82. Taibah, S.M. Dental Professionalism and Influencing Factors: Patients' Perception. *Patient Prefer Adherence* **2018**, *12*, 1649–1658, doi:10.2147/PPA.S172788.